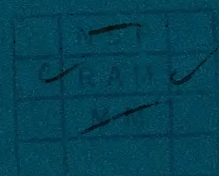


ANNUAL REPORT

1960

RUBBER RESEARCH INSTITUTE OF MALAYA



Correction

1960 Annual Report

Page

16 *Line 17, for heated read treated*

Corrections

1959 Annual Report

Page

- 53 *Line 16, for* The value of constants, that is coverage, unit plant size and density, can be used as standards of comparison *read* Estimates of coverage, unit plant size and density, can be used as means of comparison.
- 79 *Line 21, for* tear strength and resilience *read* tear strength and abrasion.

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1960

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RUBBER RESEARCH INSTITUTE OF MALAYA

ANNUAL REPORT
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Published 1961

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CONTENTS

	Rep.	Rubb.	Res.	Inst.
	Malaya			
REPORT OF THE BOARD	3			
REPORT OF THE ACTING DIRECTOR	6			
SOILS DIVISION	20			
Research	20			
Advisory	35			
BOTANICAL DIVISION	36			
Research	36			
Advisory	62			
PATHOLOGICAL DIVISION	63			
Research	63			
Advisory	69			
CHEMICAL DIVISION	71			
Fundamental Research	71			
Applied Research and Technology	80			
Process Evaluation and Factory Studies	84			
Advisory and Technical Services	88			
SMALLHOLDERS' ADVISORY SERVICE DIVISION	95			
Advisory	97			
Information and Education	109			
ESTATES ADVISORY SERVICE DIVISION	115			
PUBLICATIONS AND INFORMATION	118			
PUBLICATIONS OF THE R.R.I.M. 1960	120			
R.R.I.M. EXPERIMENT STATION	124			
<i>Appendix</i>	129			
Senior Staff and Graduate Assistants	129			
Accounts	132			
Map (folding): Experiment Station, Sungei Buloh				

THE RUBBER RESEARCH INSTITUTE OF MALAYA

The Institute was established under the Rubber Research Institute of Malaya Enactment 1925, amended in 1934. It was founded for the purpose of research into rubber production in all its aspects and for the provision of information on the results of research. Funds are provided by a voluntary cess on the exports of rubber from Malaya. Contributions are also received from other producing territories—Nigeria, Sarawak, Brunei and North Borneo. The Institute is administered by a board consisting of Government nominees and selected representatives from planting organisations.

Three Divisions, Soils, Botanical and Pathological, are concerned with the cultivation of the rubber tree and the harvesting of the crop. The Chemical Division carries out investigations into the conversion of the crop into marketable forms. There is also a Statistics Division and a Publications and Information Section which includes the Library.

The Smallholders' Advisory Service has the task of conveying the results of research to the large rubber smallholding community of Malaya. An Estates Advisory Service has also been formed which will provide routine advice to all estates, that is all planted areas over 100 acres.

The main research buildings are at Kuala Lumpur. The Experiment Station, about 3,000 acres in extent, is at Sungei Buloh, 16 miles from Kuala Lumpur.

Report of the Board

On 31 December 1960, the members of the Board, under its Constitution as prescribed by the Rubber Research Institute of Malaya Enactment No. 14 of 1934, were:

- a. The Acting Director of the Institute (Mr C. G. Akhurst), Chairman
- b. The Assistant Secretary to the Treasury (Mr Lim Kim Cheng, M.C.S.)
- c. The Acting Director of Agriculture (Mr J. S. Ure)
- d. Members appointed under section 5(i)(b) of the Enactment (F.M.S. Cap. 108) to represent Smallholders:

The Hon'ble Enche Abdul Jalil bin Haji Aminudin, P.J.K., J.P.
Mr Yap Kim Hock, J.P.

- e. Members appointed under section 5(i)(b) of the Enactment (F.M.S. Cap. 108) to represent the Rubber Producers' Council, Rubber Growers' Association and the Malayan Estate Owners' Association:

Mr A. W. Goode
Mr Soon Cheng Sun, J.M.N., J.P.
Mr J. Brown
Mr S. Sandison
The Hon'ble Mr Choo Kok Leong

Mr C. E. T. Mann retired from the post of Director of the Institute with effect from 31 January 1960 and Mr C. G. Akhurst was appointed by His Majesty the Yang di-Pertuan Agong to act as Director until the arrival of the new Director, Dr C. C. Webster.

Mr J. C. Mathison, O.B.E., P.K.J. retired from the Board in September and Mr Soon Cheng Sun was appointed in his place.

The Acting Director of Agriculture, Mr A. L. Barcroft, left Malaya on retirement in April and Mr J. S. Ure was appointed a member of the Board in his place.

Mr J. Brown was on leave from Malaya from mid-July until mid-October 1960 and Mr L. H. N. Davis was appointed to act for him on the Board during his absence.

The Permanent Committee. The members of the Permanent Committee consisting of five Board members were:

The Acting Director, Mr C. G. Akhurst, Chairman
The Financial Member, Mr Lim Kim Cheng, M.C.S.
Mr J. C. Mathison, O.B.E., J.P.
The Hon'ble Mr Choo Kok Leong
Mr J. Brown or Mr L. H. N. Davis

The Minister of Commerce and Industry appointed Mr Brown to be a member of the Permanent Committee with effect from 26 February 1960 to fill the vacancy caused by the resignation of the Hon'ble Mr Choo Kok Leong.

Mr L. H. N. Davis acted on the Permanent Committee for Mr J. Brown while he was away from Malaya on leave from mid-July until mid-October 1960.

Meetings of the Board and Permanent Committee. During 1960, the Board held three statutory meetings, as well as one to consider Programmes of Work and Estimates of Expenditure for 1961, which was attended by Sir Geoffrey Clay, Controller of Rubber Research. One special meeting was held at the Experiment Station. At the statutory meeting on 4 August, Mr H. C. Bugbee, Chairman of the Natural Rubber Bureau, Washington, was present and gave an account of the work of the Bureau in the U.S.A. The Permanent Committee met four times, with two extra meetings for Estimates and one as a Selection Committee.

Ad hoc Committees of the Board met on several occasions, the one appointed to deal with houses and buildings met four times, the Selection Committee four times, the Land Acquisition Committee twice, the Joint Committee of the R.R.I.M. and the R.R.I. Staff Union twice and the Retirement Benefits Committee once.

The Board continued to receive the advice and assistance of the London Advisory Committee, whose Selection Sub-Committee and Agricultural Sub-Committee met on several occasions.

Policy. The Board continued to function under the present R.R.I.M. Enactment as the authority directly controlling the R.R.I.M., although it will cease to exist when the Enactment is revised in accordance with the plans announced by the Controller of Rubber Research.

An International Natural Rubber Research Conference was held in Kuala Lumpur from 26 September to 1 October 1960; it was attended by 280 delegates and 79 papers were delivered.

Other important developments of the Board's policy were:

- a. The first meeting of the Joint Committee of the Rubber Research Institute Staff Union and of the Rubber Research Institute of Malaya was held in February, the constitution of the Joint Committee having been mutually agreed and accepted by the Board R.R.I.M. and the R.R.I. Staff Union in a Memorandum of Agreement. The main objects of the Joint Committee are to provide a constitutional means of consultation and negotiation between the Board and the Union and generally to promote and improve relationships between the two bodies.
- b. The Board agreed that RRIM 600 series clones should be released from agreements prohibiting the propagation for resale of budwood, with effect from 1 January 1960 for purchasers in Malaya, North Borneo, Sarawak, Brunei and Nigeria.
- c. A request was received through the Ministry of Commerce and Industry from the High Commissioner of India in the Federation of Malaya for the services of three Rubber Experts, and, under the Colombo Plan, three members of the staff of the R.R.I. visited and reported on the major rubber growing areas in South India.
- d. The Board agreed that an Annual Conference for Planters should be held, the first to be in 1961.

Report of the Board

- e. Two Research Officers and one Smallholders' Advisory Officer visited Nigeria at the request of the Nigerian Government, to advise on a programme of research for developing the rubber planting industry in that country.
- f. An *ad hoc* Committee of the Board on the expansion of the Smallholders' Advisory Service submitted a report which was accepted in principle by the Board.

Finance. The Board's approved estimates of expenditure and revenue are given below (the audited accounts appear at the end of this report):

		<i>Approved Estimates</i>	<i>Actual Expenditure</i>
Headquarters and Laboratories		\$ 6,737,492	\$ 5,880,673
Experiment Station, Sungei Buloh		1,065,088	1,044,085

Staff. The departure on retirement of Mr C. E. T. Mann on 31 January 1960, after serving in the Botanical Division since June 1927 and as its Head since 1931, and finally as Director and Chairman of the Board since 1946, headed the list of losses of senior staff.

Mr L. R. Davidson, Head of the Estates Advisory Service resigned and the vacancy was filled by the promotion of Mr F. W. Hutchison of the Pathological Division. Mr G. Owen who retired from the post of Head of Soils Division was succeeded by Dr G. A. Watson of that Division.

During 1960 three Division A officers took up appointments, one being promoted from Division B, and eight new Division B officers were appointed. At the end of the year there were vacancies on the establishment for ten Division A and six Division B officers.

As Acting Director and Chairman of the Board from 1 February to the end of the year, I would like to record my sincere appreciation of the cordial relations and friendly co-operation I have experienced with the staff of the Institute, to whom I offer my good wishes for the future.

C. G. AKHURST

Acting Director and Chairman of the Board

Report of the Acting Director

The year 1960 was a period of transition and change, during which a number of innovations were made, notably in the constitution of the authorities governing the Institute.

Revision of the Constitution

The revision of the Rubber Research Institute of Malaya Enactment was begun, and when the new Enactment comes into force probably in 1961, the present R.R.I.M. Board will cease to exist and its functions as the controlling body under which the Institute operates will be taken over by the Malayan Rubber Fund Board.

In July, an inaugural meeting was held in London of the Co-ordinating Advisory Committee, which has been appointed by the Malayan Rubber Fund Board to advise on the work of the organisations financed by it. The Committee met again in October to consider the 1961 programme of work and estimates of expenditure of the Institute as well as those of its sister bodies, the Natural Rubber Producers' Research Association and the Natural Rubber Bureau, both of which are also financed by the M.R.F.B.

The inauguration of this Committee rendered the London Advisory Committee redundant. The last meeting of the L.A.C. took place in June 1958 and it formally ceased to exist on 31 December 1960, after nearly thirty years of invaluable aid to the Natural Rubber Industry in Ceylon and Malaya. R.R.I.M. staff have been particularly grateful for the comments which the members of the Agricultural Sub-Committee of the L.A.C. have made on the annual research programmes of the Institute. The last meeting of the Agricultural Sub-Committee was held in January 1960.

Senior Staff Changes

During the year three of the most senior officers of the Institute retired. The Director, Mr C. E. T. Mann, retired in January after thirty-three years' service, the Head of Soils Division, Mr G. Owen after twenty-two years' service and the Head of the Estates Advisory Service, Mr L. R. Davidson, after twenty years' service. Tributes to these three officers for their services to the rubber industry in Malaya have been paid elsewhere, but it is fitting to record here the regret felt by all members of the Institute when they departed. It is not easy to replace experienced staff of long service but the need for these replacements had been foreseen, and the two vacancies for Heads of Divisions were filled by promotions from within the existing Institute staff. Dr G. A. Watson was made Head of the Soils Division and Mr F. W. Hutchison Head of the Estates Advisory Service. By the middle of the year Dr C. C. Webster, previously Professor of Agriculture and Acting Principal of the Imperial College of Agriculture, Trinidad, was appointed Director. He is expected to assume duty early in 1961.

Conferences

A major event in 1960 was the Natural Rubber Research Conference, sponsored by the Institute with the support of the Government of the Federation of Malaya and the Rubber Producers' Council. It was held in Kuala Lumpur in

Report of the Acting Director

September. The outstanding success of the Conference has already been fully acknowledged and acclaimed. All those who attended, and especially overseas members, praised the excellent organisation of the Conference, which was the result of careful planning by the Programme Committee consisting of the Heads, or Acting Heads, of the four main research divisions. The Committee was under the Chairmanship of Dr A. Newsman until 10 July, when he met with an accident and Mr C. W. Brookson became Acting Chairman. The other Committee members were Mr G. W. Drake, representing the Chemical Division, and Dr G. A. Watson, who represented and later became Head of the Soils Division. For some of its meetings the Programme Committee was joined by Mr W. G. Wren, Head of the Chemical Division. The Committee was most ably assisted by the Conference Secretary, Mrs A. Kennard, who was appointed for a year to work full-time on Conference matters.

The Conference concluded a series of international rubber meetings held in Malaya during September 1960, the previous ones being the Packing and Marketing Conference in Singapore and the Rubber Study Group meeting in Kuala Lumpur. Both were attended by officers of the Institute. Mr G. W. Drake attended certain sessions of the third International Rubber Quality and Packing Conference and served on the Sub-Committee which formulated descriptions of special rubbers. The Acting Director, Mr C. G. Akhurst, was one of the official delegates of the Government of the Federation of Malaya to the 15th International Rubber Study Group Meeting, and was a member of the Development Sub-Committee.

Visits Overseas by Staff

Members of staff made a number of important visits to countries outside Malaya, conferring with members of other research organisations participating in international meetings and undertaking special assignments. The benefits to be derived from such visits, notably through the exchange of information and ideas and through the co-operative work which the visits facilitate, should not be underestimated. A summary of these visits is given below:

Dr P. R. Wycherley, Botanical Division, to research institutes and commercial organisations concerned with *Hevea* in Brazil, Costa Rica, Guatemala, Panama and Trinidad, in February/March; to R.R.I. Ceylon en route to Malaya, in April.

Mr C. W. Brookson, Botanical Division, *Dr A. Newsam*, Pathological Division and *Dr G. A. Watson*, Soils Division, to study and report on the *Hevea* plantation industry in South India, in April. The visit was made at the request of the Government of India and was arranged by the Ministry of Commerce and Industry under the terms of the Colombo Plan.

Mr G. H. Tinley, Botanical Division, to view work on budgrafting techniques in North Borneo, in May.

Mr C. G. Akhurst, Acting Director, to the International Rubber Research Development Board meetings in Paris, in July.

Mr B. C. Sekhar, Chemical Division, to the International Symposium on Macromolecular Chemistry in Moscow, in July.

Mr R. A. Fox, Pathological Division, to the Sixth Mycological Conference in London, in July.

Mr M. M. Guha, Soils Division (on a three-year course at Macaulay Institute, Aberdeen), to the Seventh International Soils Science Congress at Wisconsin, U.S.A. and to soil research centres in the United States, in August and September.

Mr C. G. Akhurst, Acting Director, and *Mr W. G. Wren*, Chemical Division, to the Co-ordinating Advisory Committee meetings in London, in November. *Mr Akhurst* also visited the Natural Rubber Bureau in Washington, U.S.A., the Pineapple Research Institute in Hawaii, and the Foundation for Natural Rubber Research and Development in Tokyo, during his journey back to Malaya; *Mr Wren* also had discussions on research at the Natural Rubber Producers' Research Association, at the Dunlop Research Centre and with Dr S. E. Jacobs at the Imperial College, London. During the return journey to Malaya, *Mr Wren* delivered an address at the Rubber Science Hall of Fame Celebration at Akron University, toured research laboratories concerned with synthetic rubber production in the U.S.A. and Canada, and visited the Natural Rubber Foundation in Tokyo in November and December.

Mr C. W. Brookson, Botanical Division, *Mr J. E. Morris*, Chemical Division and *Mr Wong Mun Yun*, Smallholders' Advisory Service, to report on the research requirements of the *Hevea* plantation industry in Nigeria, in October and November. The visit was made at the request of the Government of Nigeria. *Mr Morris* also visited the Firestone Co. Plantations in Liberia, and *Mr Wong Mun Yun* went on to visit agricultural advisory organisations in Britain.

Mr C. A. K. Salgado, Chemical Division, to examine Technical Classification of Rubber services in Indonesia, in December.

In addition to the above visits and tours, members of the R.R.I.M. who were on leave in Great Britain were able to see the work of our sister research unit, the Natural Rubber Producers' Research Association, at Welwyn, Herts. Further opportunities for co-operation and exchanges of views arose from the visits to the Institute during the year by many scientists from overseas and from other research organisations in Malaya.

In a somewhat different category is the establishment of the *Dothidella* Research Unit at the Imperial College of Tropical Agriculture in Trinidad, to which Dr C. F. Arlett was appointed. He arrived there in August for a three year assignment. The investigations will seek to establish the genetics of the fungus *Dothidella ulei* and its interaction with *Hevea*.

Exhibitions and Shows

The Institute once again participated in the Malayan Agri-Horticultural Exhibition which was held in Kuala Lumpur in July. The exhibition featured important aspects of the work of the Soils Division, Chemical Division and Advisory Services and was very well attended. An innovation was that the R.R.I.M. exhibition area was completely closed in and fully air-conditioned.

Report of the Acting Director

A further display of the Institute's research and advisory work was seen at the exhibition held in August to mark the end of the Emergency.

Staff of the Smallholders' Advisory Service made noteworthy contributions of educational value to smallholders at all the major agricultural shows held throughout the country.

Training

Over thirty courses were organised by the Smallholders' Advisory Service for training its staff, owners of smallholdings and others engaged in rubber work. The courses were also able to accommodate a few overseas trainees from time to time, of whom fifteen came from Sarawak, three from Thailand and one from the Sudan.

Four refresher courses for Senior Estate Conductors, held at monthly intervals, were organised at the Experiment Station in the middle of the year.

The Board of the R.R.I.M. has continued its policy of assisting members of the staff to obtain further training overseas leading to higher degrees and better qualifications, as well as offering scholarships at the University of Malaya and at the College of Agriculture. The following Research Officers, all Division B officers, were undergoing training at Research Institutes overseas at the end of the year:

Mr M. M. Guha of the Soils Division, completed the second year of his three-year course at the Macaulay Institute for Soils Research, Aberdeen, Scotland, where he is studying trace elements in soils and spectro-chemical analytical techniques. He expects to present a thesis for a Ph.D. degree at the end of his studies. He is being given financial assistance by the Board of the R.R.I.M. towards his subsistence expenses.

Mr J. S. Soosai, of the Library, completed one year of the two-year course in the School of Librarianship at the North Western Polytechnic, London. On completion of the course he will be returning to take up the post of Librarian. He has an R.R.I.M. scholarship.

Mr A. Karunakaran of the Chemical Division commenced a two-year course in Plant Biochemistry at Purdue University, Lafayette, U.S.A. and hopes to obtain a Master's degree. He has been awarded a travel grant by the Asia Foundation and a scholarship at Purdue University. He is on unpaid leave.

At the University of Malaya the following undergraduates were studying with the aid of scholarships awarded by the Board of the R.R.I.M.

Mr E. Pushparajah and *Mr Lim Tow Ming* commenced three-year and four-year courses respectively, in May at the University in Kuala Lumpur. The courses are in agriculture and lead to a B.Sc. degree.

Mr Chin Peng Sung and *Mr Yoon Pooi Kong* at the University in Singapore; both completed the three-year course on which they were awarded a pass degree B.Sc. and both proceeded to the fourth year of the course leading to an Honours degree.

Several scholarships awarded by the Board of the R.R.I.M. were held by students at the College of Agriculture, Serdang, Selangor, who were training for future service as Rubber Instructors in the Smallholders' Advisory Service. Ten were in the first year, five in the second year and six in the third year.

Under the auspices of the Colombo Plan for Technical Co-operation in South East Asia, Mr Ong Yoke Fong, Senior Computer in the Statistics Division, was selected by the Malayan Trades Union Congress to attend a Trade Union training course in Ottawa, Canada. He attended the course while on leave, which covered a period of five months to the end of February, after which he visited trade union headquarters in London, Brussels and Geneva on his way back to Malaya.

University of Malaya

The Acting Director attended the meeting of the Court of the University of Malaya held in June in Singapore, and also represented the Institute at the convocation for the award of degrees.

The Department of Economics in the University of Malaya again received assistance from Mr A. Fong Chu Chai of the Statistics Division, who, because of the acute shortage of University staff in that Department, gave a short course of lectures and tutorials.

Administration

Preliminary discussions took place at the end of the year with the Adviser, Organisation and Methods Division of the Treasury, who is to undertake an investigation of the arrangements for the handling of the administrative work of the Institute.

In view of the greatly increased volume of accounting work which the expansion in recent years of the staff and activities of the Institute has caused, the Board approved the appointment, to be made early in 1961, of a qualified accountant to assist in the control of the Institute's finance.

RESEARCH AND ADVISORY

The main policy of the Research Programme has followed the lines laid down by the overall plan for the five year period 1958 to 1962 which is based on the recommendations of the Blackman Committee Report.

The basic objectives of natural rubber research are to achieve production costs which are competitive with, or better than those of synthetic rubber, to produce natural rubber of improved quality (including entirely new preparations) which will be at least as attractive to the consumer as synthetic products, and to find new uses for existing types of rubber. The work of the Institute falls into two principal fields, one biological and directed towards increasing efficiency in crop production, the other concerned with the chemistry and technology of improving the quality of the product.

The main lines of the biological research programme are planned to give increased growth rate, earlier maturity and higher yields, all evolving from a combination of efforts by the Botanical, Soils and Pathological Divisions:

- (i) to derive new planting material by plant breeding and selection;
- (ii) to develop better growing techniques under optimum soil management and cover plant systems, with fertiliser programmes to compensate for soil nutrient deficiencies;

Report of the Acting Director

- (iii) to improve the health of the tree and to reduce diseases and loss of trees;
- (iv) to extract maximum quantities of latex from the trees through suitable tapping techniques and the use of yield stimulants.

The work on the product is the function of the Chemical Division, where, in addition to basic research under the main headings of biochemistry, microbiology, colloid chemistry and polymer chemistry, investigations are being made on the drying of rubber, on production techniques, on problems concerned with latex and dry rubber technology and on various aspects of field and factory techniques.

Once the latex has left the tree, the grower needs the assistance of the chemist in preparing and offering his product for the market by the best possible methods. The chemist's ultimate aim is to advise the producer how best to reduce production costs, present the rubber or latex as a marketable commodity of the highest quality and at the most uniform level, and, by modified processes, prepare new speciality rubbers.

Complementary to and supplementing the research investigations of the Institute, is the dissemination of the results of experimental work which is achieved chiefly by three services, the long established Smallholders' Advisory Service, the recently constituted Estates Advisory Service and the Chemical Division Advisory sections. These services help producers, both estates and smallholders, to utilise the results of field and laboratory investigations to achieve improved extraction of rubber from the tree and to prepare it in an acceptable marketable form; they also assist in overcoming some of the problems of local manufacturers. Expansion and development have been the keynotes for both the Smallholders' and the Estates Advisory Services, the former by a steady annual increase of Rubber Instructors and Assistant Rubber Instructors so that in three to four years time each 5,000 acres of smallholdings will be served by one Assistant Rubber Instructor, and the latter by building up the approved establishment of qualified and trained senior staff as quickly as possible.

The expenditure on all advisory work is estimated to be between 30% and 40% of the total expenditure of the Institute.

It is customary for the Director to report in brief on the major lines of work which have been pursued by the several Divisions of the Institute and in the following pages summarised versions of the research progress are presented. Readers who are interested in further information can obtain this from the detailed Divisional sections which follow in the main body of the report.

SOILS DIVISION

The main activities of the Soils Division are concerned with the effects of fertilisers and cover plants on the growth and yield of the rubber tree, the use of leaf analysis for diagnosing the nutrient requirements of the tree and the control of weeds by herbicides. A considerable amount of laboratory work arises from these undertakings as well as from routine analyses of soils and fertilisers, and a constant effort is made to improve analytical techniques. Pot culture studies are being carried out chiefly for comparison of soluble sources of phosphate together with some lysimeter studies.

Manuring of Hevea

Apart from the established major growth responses of mature rubber trees to phosphorous and nitrogen, early improvement in growth has been observed in three experiments on young mature trees on inland soils following the use of potash fertilisers, whilst on mature trees a nutrient deficiency has been corrected, and a growth response obtained, following treatment with 4 oz per tree of manganese sulphate.

There were relatively few statistically significant yield responses to fertilisers in the year's records, although it is early to expect any from the newer trials.

Seed fall improvement has been detected after nitrogen manuring on coastal clay soils, but on an inland soil where potash has improved tree growth, seed fall has been depressed.

Tests of wood strength of clone RRIM 501 have shown that potash and nitrogen manuring both decrease wood strength and no confirmation has been obtained of the suggestion that the potash fertilisers may reduce the incidence of wind damage in this clone.

Cultivation and Ground Covers

Efforts are continuing to find herbicides which can satisfactorily replace sodium arsenite, and results previously reported in 1959 are confirmed. Present work suggests that herbicide mixtures will probably work best when formulated for the particular composition of weed population which exists. Costs are, however, higher than for sodium arsenite.

Two new chemical herbicides, Simazine and Atrazine, show promise when used as pre-emergence applications.

In the control of leguminous ground covers in young rubber, the results from one experiment show that strip weeding may be practised up to eighteen months after planting with seedlings, or six months after budding in the field, and then discontinued with no harmful effects, provided that covers are kept away from the trees.

Comparisons of different ground covers on the growth of young rubber trees reveal that legume creepers may have a greater effect than normal applications of fertilisers on typical inland soils. *Mikania scandens*, on the other hand, checks tree growth considerably.

Pot Culture Experiments

Pot culture and lysimeter experiments are giving information on the movement of, and changes in nutrients when added to the soil. Some of the results indicate a slight retarding effect from the use of superphosphate which may be related to interference with the absorption of trace elements by the rubber seedlings.

Analysis

Work is progressing on a number of new methods of laboratory analysis of soils and plants, as well as on comparisons with results obtained by other laboratories in Malaya.

Report of the Acting Director

Plant Investigations

A major project has been the study of leaf analysis and the testing of the method of 'Physiological Diagnosis'. Arising from these studies have been observations of the wide incidence of manganese deficiency, of magnesium deficiency in clone PB 86 and of calcium deficiency as a tentative diagnosis of the cause of a white leaf scorch.

Difficulties have been met in translating directly into Malayan practice some of the procedures for physiological diagnosis which have been developed in Vietnam, and in general latex analysis is considered of doubtful value in Malayan conditions.

Advisory

The amount of advisory correspondence and visiting carried out by Soils Division remained at the 1959 level, despite the fact that routine advisory work was taken over by the Estates Advisory Service in 1959.

BOTANICAL DIVISION

The Botanical Division is mainly concerned with breeding and selection, propagation and planting procedures, tapping systems and yield stimulation, the physiology of the tree and ecological studies.

Breeding and Selection

Over 46,000 hand pollinations were made in 1960, a considerably greater number than any previously recorded, resulting in one large family, several exploratory families and some experimental crosses, with an overall low percentage of successes (3.2%).

Selection of clones of the RRIM 700 series from the small scale trials were made for large scale testing. In the fifth year of tapping of '600' series clones at the Experiment Station, clone RRIM 600 became the highest yielding. The Chemical Division extended its testing of the latices of many of the newer clones. In the Exchange Clones trial, the growth performance of clone RRIM 701 was outstanding, with an average girth of 12.7 inches three years after budding.

Propagation and Planting Methods

The crown budding trials confirmed the highly significant effects of the crown clone on growth, although the effect of the trunk clone is not established.

Considerable work has been done in developing and improving the techniques successfully established in 1959 for producing rooted cuttings. Comparisons are being made between the rooted cuttings and budded stumps, and rooting habits are being closely studied.

Tests are being made of the methods successfully used by the Department of Agriculture in North Borneo, of budding 4 to 5 month old stocks with green budwood, with the object of having usable stumped buddings only a year after planting the seed.

Investigations on wind damage followed several lines: with the co-operation of the Forest Research Institute, tests of timber strength have continued and have

been made under different planting densities; studies are progressing on pruning and pollarding treatments and on the effect of postponement of tapping. No conclusive results are yet available.

Tapping

Brown bast incidence in clonal seedling trees is being examined under a variety of systems of tapping in an experiment now in the fourth year, and observations on growth and yield are also being taken. High or ladder tapping and intensive tapping continue to give interesting information and some of the results were given in detail at the Natural Rubber Research Conference.

A study of tapping intensity in relation to manuring and the use of yield stimulants shows, in the third year of tapping, no outstanding effects of fertilisers on the responses to stimulation.

Physiology and Morphology

Further search for new and satisfactory chemicals has failed to improve on 2,4,5-T and 2,4-D as yield stimulants. More detailed tests are in progress comparing methods of scraping bark.

The physiological aspects of stimulated latex flow are receiving continued and greater attention, involving observations on the extent of, and changes in the latex drainage areas, the rate of flow of latex and its composition. Discussions held during the Natural Rubber Research Conference gave considerable impetus to this work.

Ecology

Long established pre-war trials of covers at the R.R.I. Experiment Station show that growth of rubber is best under leguminous creepers. Other covers, *Panicum nodosum*, *Flemingia congesta* and *Axonopus compressus*, have an intermediate effect, while *Mikania scandens* and *Eupatorium odoratum* had the greatest retarding effects.

Trials have been started with the idea of reducing the competitive effect of grass on rubber trees by regular mowing, and of maintaining legumes by heavy dressings of phosphate, but definite results are not yet evident.

Some work has commenced to ascertain the optimum size and shape of plots.

Advisory

With the routine advisory visiting and correspondence being handled by the Estates Advisory Service, the Divisional correspondence was mostly on specialist matters and showed a slight reduction over 1959.

PATHOLOGICAL DIVISION

Root Disease

Research on root disease remains the major project of the Division. Fungicidal paint and grease for preventing the spreading of fungus have given promising results when applied to the collars of young trees inoculated with *Fomes lignosus*. Fundamental research has continued with studies of growth rates of single spore

Report of the Acting Director

isolates of *F. lignosus* and these indicate that a continuous range of varying growth rates exists. A detailed study of the nomenclature of the fungus was made in the United Kingdom.

Tree and Stump Poisoning

Field experiments on root disease are usually long term and interim reports and results which are quoted should not be regarded as a basis for drawing positive conclusions. Further experiments were started to determine the role played by spores from diseased stumps in spreading *Fomes*. Effects of stump treatment on future incidence of disease show that, in one previously established field experiment, the incidence of disease was higher after stump poisoning with 2,4,5-T or sodium arsenite than after poisoning the standing trees, and later felling them after one month or two months. In another experiment started in 1957, little difference in incidence and loss figures was found between treatments to test varying degrees of eradication of root disease from the old stand at the time of clearing.

From other current experiments on prevention of root disease no benefits are showing from the treatment with fungicides of surfaces of infected roots or tree collars.

New experiments have been initiated to investigate various aspects of poisoning of jungle trees and stumps on the subsequent incidence of root disease in the rubber which is later planted on the land.

Decay of Rubber Wood

Observations are continuing at the Experiment Station from several experiments on the decay of rubber wood after poisoning the old trees and stumps, and include monthly listings of fungal bodies appearing on the poisoned stumps. It is reported that decay proceeds more rapidly from stump poisoning than poisoning the standing trees, and that 2,4,5-T produces more rapid decay than sodium arsenite.

Panel Branch and Leaf Diseases

No new panel and branch disease problems have appeared. Attention is still being given to the control of Birds Eye Spot. Sulphur dusting during the main flowering season, carried out at the Experiment Station, has increased seed production of RRIM 501 and Tjir 1.

Pests

Cockchafer have been further investigated using several forms of traps and different light sources for collecting them during the flying season. Heptachlor has proved superior to aldrin in soil penetration and in killing cockchafer grubs more quickly.

Advisory

Although routine advisory work was handed over to the Estates Advisory Service in the second half of the year, virtually freeing one officer for research investigations, a number of special advisory problems have been referred to the Division, and some of the more interesting aspects of these are listed in the detailed report of the Division.

CHEMICAL DIVISION

The principal aims of the Chemical Division are cheaper production costs and products of better quality, and are grouped under three main headings of Fundamental Research, Applied Research and Technology, and Process Evaluation and Factory Studies.

Fundamental Research

Biochemistry. The eleven different zones which separate in fresh latex when it is centrifuged under refrigeration at high speeds are not peculiar to any one clone, and work is proceeding on the identification of the component particles of the different zones.

Various methods are being tested with some success for separating the proteins in latex, and the first examinations of non-protein nitrogenous constituents of latex have commenced.

Microbiology. Improved techniques have been developed for counting and identifying bacteria in latex, and efforts are being continued to assess the effect of bacterial contamination on latex properties. The volatile fatty acid test remains a useful measure of bacterial activity.

Attempts are being made to improve latex flow by decreasing the bacterial contamination of the trees. The tapping panels are being heated with bactericides and antibiotics, including gaseous treatment.

Colloid chemistry. Microscope studies of the zones in centrifuged latex have shown some interesting complexities of the structure of particles which have been isolated. The identification and examination of these may be of importance in relation to studies of the biosynthesis of latex. Comparisons made between latex obtained by tapping and that from latex vessels in bark show that there are a number of points of similarity.

Hevea latex has been compared with that from a number of other lactiferous plants, and a number of plants have been found in which vacuolar particles occurred with a morphology analogous to the lutoids of *Hevea* latex.

Polymer chemistry. The importance of aldehyde groups in the reactive centres of fresh rubber has been further demonstrated and may account for changes (hardening) in rubber which occur during transport.

New types of SP rubbers have been prepared by using various different additives, and some work has been done on preparing new graft polymers.

Drying of coagulum. The work to date has been published, giving the main results on relationships between drying time and temperature, humidity of drying air and sheet thickness.

Applied Research and Technology

Latex technology. Extensive tests have been made of new preservatives, and of new and more rapid methods of assessing them. Work is in progress on the effects of fertilisers on latex properties and on differences between latices of the newer clones. Methods are being developed for evaluating preserved latices for rubber latex foam.

Report of the Acting Director

Rubber technology. A new mill-shrinkage test for SP rubbers has been evolved. A series of rubbers with a high content of non-rubber constituents has been prepared and tested, and preliminary investigations commenced on blending them with synthetic rubbers.

Process Evaluation and Factory Studies

Laboratory and design studies. It has been shown that minimum drying costs are obtained when a drying unit operates at 40% relative humidity, and higher-temperature drying will be studied using an oil-fired drier. The possibility is being considered of developing means of obtaining thinner coagulum as a way to lowering costs.

Pasteurisation as a means of preserving latex against putrefaction has been found too costly as a commercial procedure.

Studies of ammonia recovery from latex skim have progressed satisfactorily and this may be an advantage in preparing skim rubber.

Large scale investigation. A new double 'B' Smokehouse was nearing completion and construction and operation details were made available to estates; a new drying procedure for PA 80 was worked out, and for effluent disposal a trickling filtration process was shown to give marked reduction in biological oxygen demand (B.O.D.) of factory wastes.

Advisory and Technical Services

General. Routine laboratory and advisory work forms an appreciable part of the activities of the Chemical Division staff and the enquiries arise from producers and users in Malaya as well as from technical problems of consumers referred by the technical service staff from countries outside Malaya, including Great Britain, the United States of America and Eastern countries.

The work of the advisory service to estates, measured in terms of the numbers of enquiries, increased by 15% over the 1959 level.

Technical Classification of rubber remained at the same rate as in previous years, with consumer interest mainly confined to the smaller factories.

The technical service to rubber manufacturers, started at the end of 1959, has increased markedly, with some enquiries from other neighbouring countries.

STATISTICS DIVISION

The staff of the Division was heavily engaged in assisting in the preparation of papers for the Natural Rubber Research Conference, and there was an overall increase in the volume of data received from field and laboratory experiments.

PUBLICATIONS AND LIBRARY

The Publications Section had an exceptionally active year, because in addition to the normal issues of the *Annual Report*, the *Journal* and *Planters' Bulletin*, it had the heavy task of editing the large number of papers offered for the Research Conference, as well as the preparation of the Conference *Proceedings* which are

expected to be available early in 1961. In addition an up-to-date history and outline of the work and functions of the Institute was issued as an illustrated brochure.

The *Planters' Bulletin* had a successful year of publication and Parts 2, 3 and 4 of the *Journal* were issued to complete Volume 16. The appointment of two Assistant Publications Officers, one for the Chinese language and one for the Malay language, permitted a start to be made on the preparation for publication of the *Planters' Bulletin* in those two languages, the first issues being expected in March 1961.

The reorganisation and re-equipping of the Library was well under way by the end of the year after a number of interruptions had taken place, the major one being the use of the Library space as one of the two meeting rooms for the Conference. Although the Library stock was accommodated in temporary premises, this move curtailed considerably the services offered to the staff.

The reorganised Library should give shelfspace for books for a further ten to fifteen years.

SMALLHOLDERS' ADVISORY SERVICE

Proposals to meet the need for expansion of the staff of the Smallholders' Advisory Service were examined by an *ad hoc* Committee of the Board which later accepted the recommendations in principle, and plans were completed to put these recommendations into effect.

The main recruiting effort was directed towards obtaining additional Assistant Rubber Instructors who had increased to 128 by the end of the year with three Senior Rubber Instructors and twenty-one Rubber Instructors supervising them. The expansion plans aim to provide some 300 Assistant Rubber Instructors and 40 Rubber Instructors by the end of 1963.

The main restriction to expansion is the limited number of experienced supervisory officers and it is hoped to improve this by offering more scholarships to be held at the College of Agriculture, Serdang.

Advice is given to smallholders in two ways, by direct instruction to individuals or small groups and by education and information supplied to larger groups. Improvement in the method of direct advice will follow if the planned expansion programme is implemented, and at the end of 1963 there should be one Assistant Rubber Instructor to serve every 5,000 acres of smallholders' rubber.

The less direct method or group method of approach is carried on by training courses, by illustrated literature in conjunction with film shows, by illustrated posters, and by coloured slides exhibited by Assistant Rubber Instructors.

During 1960 there was a marked increase of correspondence between Headquarters and staff in the field, a direct result of increases in the numbers of Assistant Rubber Instructors, and similarly the total number of visits by field staff to smallholdings increased nearly 50% over those made in 1959.

It was not possible, however, for the R.R.I.M. field staff to visit more than 14% of the total estimated rubber smallholdings in Malaya during 1959 and 1960.

Report of the Acting Director

In new planting by individual smallholders, particularly in some States, there was a noticeable increase in the demand for budwood and a decrease in the use of clonal seedling material.

The authorities connected with both the Federal and the State Land Development Schemes showed a marked preference for budgrafting and the staff of the S.H.A.S. have been in close contact with these authorities during the early stages of the two types of Scheme. In addition, staff at Headquarters are regularly and frequently consulted by the Federal Land Development Authority.

Nearly half of the time of all field staff was occupied in advisory visits to replantings.

Some shortages of budwood material were recorded for some new plantings and replantings, and although the older clones Tjir 1 and PB 86 continue to be the most popular, newer clones are becoming known to the smallholder and a greater use of them in the future may be expected.

ESTATES ADVISORY SERVICE

In spite of this being only the second working year since its formation and despite the difficulties arising from the recruiting of staff requiring training, the scope of the Division's activities was increased to include the routine advisory work previously carried out by Soils Division as well as the routine botanical and pathological work.

Mr F. W. Hutchison, was transferred from the Pathological Division to succeed Mr L. R. Davidson as the new Head of Division. There were four other additions to senior staff.

The main effort of the Estates Advisory Service is being directed towards communicating R.R.I.M. advice to the smaller estates, where a good start has been made with Chinese owned estates, which were systematically canvassed in 1959. A similar approach to the smaller Indian estates commenced late in 1960 and will be continued in 1961.

Advisory correspondence and the number of visits to estates have both increased, particularly in the second half of the year. All topics for advice have been covered but it is noticeable that methods of tapping and yield stimulation are still relatively little understood and could be greatly improved.

C. G. AKHURST
Acting Director

Soils Division

Dr G. A. Watson was appointed Head of Division in May, following the retirement of Mr G. Owen.

Mr K. Ratnasingam was promoted to Division B at the beginning of the year and Mr Wong Phui Weng joined the Division, also as a Division B officer, in August.

RESEARCH

MANURING OF HEVEA

After the extensive changes in the field experimental programme last year, 1960 has been a year of consolidation with emphasis on more intensive recording and analyses of the results from each experiment.

The numbers of experiments in progress at the beginning and end of 1960 were as follows:

	<i>Dec. 1959</i>	<i>Dec. 1960</i>
Manuring experiments, mature rubber:		
(a) on estates	11	12
(b) on the Experiment Station	9	9
Manuring experiments, immature rubber:		
(a) on estates	9	8
(b) on the Experiment Station	5	8
Cover plant and fertiliser experiments:		
(a) on estates	7	7
(b) on the Experiment Station	3	3
TOTAL	44	47

A further trial has been started on an estate in Selangor with treatments based on a 'physiological diagnosis' from leaf and latex analytical data. In this instance, treatments include nitrogen, phosphate, magnesium and copper applications, together with a comparison of soluble and insoluble phosphate fertilisers.

At the Experiment Station, more land has become available for experiments in a replanted area, and experiments have been laid down to investigate potassium-magnesium-manganese relationships and the effects of different methods of application of soluble and insoluble phosphate fertilisers in the planting hole. This latter experiment follows similar investigations carried out in pots which were reported last year. A further trial, in a one-year-old jungle planting, compares several different fertiliser programmes over the period from budding to tapping, using both the normal fertiliser mixtures and more concentrated 'compound' fertilisers.

Attempts to use small plots in nursery areas and single tree plots in a terraced field, to investigate short term fertiliser effects, have not been successful mainly because heavy rainfall washed soil from one plot (or point) to another.

The Effect of Fertilisers on Growth

In the older trials in mature areas, the main response in terms of girth increment continues to be to phosphate fertilisers with a smaller response to nitrogen. However, in the newer experiments on mature rubber planted after the war, significant positive responses to potassium have been measured in three areas on inland soils and these have occurred before any response to nitrogen and phosphate has been detected. These results are surprising in view of the negative effects of potassium often reported on similar soils in the past, and it will be interesting to see whether the same pattern of effects is observed in other areas in the next few years.

A growth response has been measured for the first time in mature rubber from applications of manganese sulphate to a deficient area. The fertiliser was applied at the rate of 4 oz per tree in 1958 and 1959.

In the experiments on immature rubber, the responses were mainly to phosphate and nitrogen fertilisers on the inland soils. On coastal clay areas, the only response measured was to nitrogen in one trial.

In two trials, where treatments have been applied for two years, no difference in effect on tree growth has been found between compound fertilisers incorporating water-soluble phosphate and the equivalent mixed fertilisers using the commonly imported ingredients, including rock phosphate.

The Effect of Fertilisers on Yield

There were comparatively few statistically significant responses in yield to fertilisers. In the older trials on estates, the variance was usually high owing mainly to large differences in stand between the plots. In eight of these trials the only effects measured were a positive one due to nitrogen and a negative one due to potassium. Most of these particular experiments have now been terminated.

In the newer trials where fertilisers have been applied for only one or two years the only effects observed have been due to potassium. In one area there was a positive effect, in another a negative effect. In an extended study of these differences in nutrient response, leaf and latex analytical data from both these areas are being surveyed.

The Effect of Fertilisers on Seed Production

Measurements of seed fall are being continued in three experiments. On a coastal clay area, a significant positive effect to nitrogen fertilisers was observed but none due to phosphate or potassium. In another trial on an inland area, where growth was significantly improved by potassium fertiliser, it was found that seedfall had been significantly decreased on these same plots. Further data are being collected in an attempt to explain this effect.

The Effect of Fertilisers on Wood Strength

In co-operation with the Botanical Division, trees of uniform girth were removed from each plot of an NPK fertiliser trial on clone RRIM 501 and the wood subjected to strength tests at the Forest Research Institute. The results showed highly significant effects of potassium and nitrogen fertilisers on wood strength, both giving weaker wood. Leaf analyses from samples collected from the same trees

gave significant negative correlations between leaf potassium and wood strength, and also a highly significant negative correlation between leaf calcium and wood strength. Other samples collected from an adjacent area confirmed these correlations. The suggestion that application of potash fertilisers will increase wood strength and thereby reduce the incidence of wind damage is not, therefore, substantiated.

CULTIVATION AND GROUND COVERS

Weed Eradication

Weed control in planting rows. Work on this problem has again been concentrated on a search for effective substitutes for sodium arsenite. In a series of ten experiments the conclusions put forward in last year's *Annual Report* have been supported, with confirmation that sodium chlorate, Lallicide, dalapon and aminotriazole are the most effective grass killers available. PP910, a more soluble formulation of K8606, a chemical tested last year, has also proved to be a very effective contact herbicide when applied at rates of up to 4 lb per acre.

Sodium chlorate, applied at 20–25 lb per acre, is likely to come into greater use as a grass-killer when the proposed ban on sodium arsenite is introduced. While this chemical is an effective contact herbicide its effect is not persistent, lasting little more than a month, but tests have shown that this can be appreciably improved by applying it in mixture with either dalapon or aminotriazole at 4–5 lb per acre, when effects have been observed to last for up to six months. Lallicide applied at 25 lb per acre has given good results against mixed grasses. PP910 shows considerable promise, but more information regarding price and availability is required before recommendations can be made.

Where grasses occur in mixture with broad-leaved weeds, the most usual being the creeper *Mikania scandens*, the incorporation of 2 lb per acre of 2,4-D (Fernoxone) in the herbicide mixture has proved very effective.

Trials have emphasised the importance of formulating herbicide mixtures according to the composition of the weed population, and a more sophisticated approach to weedkilling will be required on estates than in the past, when the almost universally effective sodium arsenite was available. The herbicides used to replace sodium arsenite are appreciably more expensive and work is in progress concerning frequency of spraying and costs of application when using the replacement herbicides.

Use of pre-emergence herbicides. Pre-emergence herbicides are chemicals which, when sprayed on clean-weeded soil, prevent the germination and subsequent development of weed seeds. Two such herbicides, Simazine and Atrazine, have received further testing in 1960, and work has shown that the method of application may be quite critical. Applied in mixture with normal herbicides they have produced but little enhancement of effect in general. When applied one or two weeks after weed growth has been killed by normal herbicides, and before regeneration of the weeds from seeds has begun, both these chemicals have markedly prolonged the clean weeding effect. Atrazine has been found to be more effective than Simazine when applied in this manner, at rates of 15 lb per acre. Applied to clean-weeded planting rows at either 5, 10 or 15 lb per acre, both Simazine and

Atrazine have rendered hand weeding unnecessary for a period of over five months. This work needs to be repeated however under a range of planting row conditions, before practical recommendations can be made.

Bracken control. The small scale trials reported last year have been terminated. Aminotriazole, Fernoxone and dalapon, applied at 15, 5 and 15 lb per acre respectively, were relatively ineffective against bracken (*Gleichenia linearis*). Floroxone applied at the rate of 4 pints in 100 gal. water per acre, and Weedone Brackcontrol at 12 pints in 100 gal. water per acre gave good control for up to eight months after spraying.

Bamboo control. Regeneration of bamboo is sometimes a problem in new plantings and a trial has been carried out, in co-operation with the Forest Research Institute, on the effect of herbicides on *Gigantachloa levis*, a large bamboo. Seventy-two clumps of bamboo, each with about fifteen stems, were involved in the experiment, half of the clumps being slashed to ground level before treatment. All treatments were applied at the rate of 4 pints per clump, either sprayed on to the cut stumps or on to the bottom three feet of stem. Sodium arsenite at up to 7½% concentration had little effect, but sodium chlorate at 20 and 40%, Lallicide at 10 and 15%, dalapon at 5 and 7½%, and aminotriazole at 2½, 5 and 10% concentrations, all had drastic effects on the bamboo, with the higher concentrations giving complete kill in all cases. Lallicide at 10% concentration may prove to be the cheapest treatment to use in the field. 2,4,5-T painted on to the stems had little effect on growth. No advantage due to slashing appeared in this experiment so that this expensive, and arduous, operation can be dispensed with in the field when using herbicides.

Control of Ground Covers and Effect on Tree Growth

An experiment commenced five years ago, comparing strip with circle weeding in a replanting with leguminous creeping covers, has been terminated. Results show that up to two years after budding trees grown under strip-weeding conditions grew better than did circle-weeded trees. The effect, although significant, was not large, representing approximately half an inch in girth at two years after budding. Since then rates of girdling by trees grown under the two systems have been similar. In this experiment weeding was carried out using changkols, and surface soil erosion was quite severe, particularly in the circle-weeded treatments.

Practical recommendations arising from this and other work are that, in plantings with leguminous creeping covers, strip-weeding should be practised for up to eighteen months after planting with seedlings, or up to six months after budding with field budgrafts, and that thereafter covers can be allowed to grow across the planting row. No adverse effect on tree growth should be found by stopping strip-weeding at this stage, provided that the covers are kept away from the trees themselves.

Comparison of Leguminous and Non-leguminous Covers and Their Effects on Tree Growth

There are five large scale experiments on young rubber in progress which involve comparisons of different cover plant systems. Results are showing that cover plant conditions can exert an appreciably greater effect on tree growth than do normal fertiliser applications. In three of these experiments, on normal inland

sedentary soils, maximum responses to fertilisers in terms of girth increments have been of the order of 10%, but differences of up to 30% have been recorded in the girthing rates of trees grown in association with either leguminous creepers, mixed grasses, *Mikania scandens* or mixed bushy covers. In another experiment, on a poor alluvial sandy soil, responses of up to 25% have been recorded for both cover plant and fertiliser treatments, while at the other extreme little response to either covers or fertiliser treatments has been recorded in an experiment on a fertile coastal alluvial clay soil.

In those cover plant experiments where differences in treatment response have occurred, trees grown together with leguminous creepers are showing the best growth by an appreciable margin, while covers of *Mikania scandens* appear, consistently, to be checking tree growth. In the most recently started experiment a significant depression in tree height due to *Mikania scandens* was recorded at six months after budding, with the young buddings showing comparatively poor leaf colour and vigour. *Mikania scandens* is not an obviously strong competitor for soil moisture and nutrients, compared with the other cover plants used, and detailed studies are now in progress in an attempt to determine the cause of this depressive effect.

Samples of rubber leaves have been taken in these experiments, and a study of the variability of soil nutrient status and of rubber and cover plant rooting densities is being made in the experiment on alluvial sandy soil. In order to study the part that cover plants play in the soil nutrient cycle, sampling of cover plant green material and dead litter is being carried out in these experiments. Data obtained from this sampling, and presented in a paper at the Rubber Research Conference, show that at two years after planting, leguminous creepers have accumulated greater quantities of nutrients than have covers of grasses or *Mikania scandens*. These quantities represent a considerable proportion of the total nutrients found in a normal stand of five-year-old rubber trees, and confirm the important role that cover plants may play in the nutrition of the rubber tree.

Small Scale Trials with Legumes

The nutrition of leguminous ground covers is being studied in small scale field trials with several points in mind. For instance, the early establishment of a vigorous ground cover can cut weeding costs appreciably, and five experiments have been commenced in 1960 to test the effect of different fertilisers and seedling rates on legume establishment. The effect of phosphatic and molybdate fertilisers on the vigour and persistence of established leguminous creepers is being tested in another five small scale experiments and data obtained from sampling of the cover plants confirm in general the results reported last year.

SOIL INVESTIGATIONS

Mineralisation of Organic Nitrogen and Phosphorus in the Soil

Work on soil nitrogen has been held up by lack of staff, but some limited work on the effect of cover plants on the ammonium and nitrate status of the soil was commenced at the end of the year. The distribution of phosphate in the 0-3 in. and 3-9 in. layers of soil under different cover plant treatments was studied, but no differences due to the treatments could be detected.

The effect on soil phosphate of ignition at about 250°C, which corresponds roughly to the temperature of cleared soil during burning, was studied on three soils—a Kedah series sandy loam, a Sungei Buloh series coarse sandy loam, and a peaty coarse sandy loam. A decrease of from 5–15% in total phosphorus took place, presumably by volatilisation, and there was an accompanying decrease in organic phosphorus of between 60 and 90% of the amount originally present. On the other hand the inorganic phosphorus increased, by 150 to 300% for the acid-soluble forms and by 40 to 400% for the alkali-soluble forms. Changes also took place in the extractable sesquioxides: for the acid-soluble forms there was an increase in the first two soils and a decrease in the peaty soil, while for the alkali-soluble forms there was an increase in all cases. None of these changes could be related to changes in the distribution of phosphate.

In a pot experiment comparing the effect of superphosphate and rock phosphate on the growth of rubber seedlings, the mobility of the different forms of phosphate was studied. The main findings were that there was very little movement of rock phosphate as a result of water leaching through the pots, whereas superphosphate moved appreciably toward the bottom of the pot; rather surprisingly, this effect was greatest in the case of pocketed superphosphate. No increase in organic phosphate could be detected as a result of adding the fertilisers, and the phosphate added to the soil was distributed between acid and alkali soluble forms of inorganic phosphate in a ratio of about ten to one. Liming seemed to increase slightly the mobility of both superphosphate and rock phosphate in the soil. The distribution of sesquioxides in the soil was also studied; almost equal amounts of acid soluble and alkali soluble forms were found, but no connection could be detected between the amounts of phosphate and the amounts of sesquioxides which could be extracted from the soil.

Leaching of Soil Nutrients and the Effect of Fertilisers on the Soil

The results of soil analyses from several more long term field experiments have confirmed the results reported last year.

In order to study in more detail the leaching of plant nutrients from the soil, a lysimeter experiment has been carried out in the greenhouse in which the leaching of different forms of nitrogen, phosphate, potassium, magnesium and manganese fertilisers has been followed. Twenty-two lysimeters were used, each containing about 100 lb of a Kedah series sandy loam soil. Watering was controlled at the equivalent of approximately one inch per week.

The results showed that the chloride ion from potassium chloride fertiliser was leached readily down the profile to appear in the leachate together with calcium, magnesium and potassium ions. A short time after the chloride appeared in the leachate, increasing amounts of nitrate were detected in leachate from the lysimeters treated with ammonium sulphate. This increased nitrogen was present over a much longer period than the chloride and significant increases could be detected at five months after application of the fertiliser. The main cation losses associated with the nitrate were calcium and magnesium with some losses of potassium.

There was also an increased loss of manganese. Throughout the experiment, no sulphate was detected in the leachate following the application of ammonium and magnesium sulphates. However extra lysimeters, opened at intervals, showed that the ion had been strongly absorbed but was moving slowly down the profile.

After six months, the experiment was terminated, the remaining lysimeters opened, and the soil analysed at different depths. As expected, the applied phosphate was all recovered from the surface inch. It was thought that the form of phosphate might have changed since increased algal growth had been observed on the phosphate-treated lysimeters; however no differences in the percentage of organic phosphate were found on fractionation using the analytical methods outlined in last year's *Annual Report*.

Many other data were collected including results on pH and urea and ammonium sulphate comparisons, which are of both practical and theoretical interest, and work is proceeding on a detailed summary of the results.

Pot Culture Studies on Phosphorus Uptake

Pot experiments with rubber seedlings. In previously reported experiments, using low levels of application, superphosphate appeared to be slightly superior to rock phosphate as a source of phosphorus for rubber seedlings. A similar pot experiment was started in an attempt to confirm this finding at rates of fertiliser application comparable with those used in the planting hole in the field, namely 4 oz of rock phosphate per pot.

After this second experiment had been running for nine months, larger plants were generally obtained from rock phosphate than from superphosphate. This is illustrated by the mean dry weights in grams per treatment at the end of the experiment, shown in *Table 1* below.

TABLE 1. MEAN DRY WEIGHT IN GRAMS OF POT PLANTS TREATED WITH ROCK PHOSPHATE AND SUPERPHOSPHATE

Treatment	Control	Rock Phosphate		Superphosphate		
		Broadcast	Mixed	Broadcast	Mixed	Pocketed
Limed	17	164	123	110	105	138
Unlimed	22	197	175	123	145	163

The interpretation of the results was made difficult by the development, after five months' growth, of copper and boron deficiency symptoms in most of the plants which had received superphosphate, but not in plants given rock phosphate. As a result there was an interference (stunting) in the growth of superphosphate plants and subsequent observations have suggested that this may be a consequence of the use of excessive amounts of soluble phosphate.

Statistical analysis has confirmed that the best method of applying rock phosphate was by broadcasting on the surface, while for superphosphate pocketing in the soil was best; for this soil type, liming was again shown to depress the response of rubber seedlings to phosphate fertilisation.

These observations indicate that experience gained with rock phosphate is not necessarily the best guide when applying soluble phosphatic fertilisers. Further confirmation of this view was provided by a pot experiment in which the same Kedah series soil was used to measure the response of rubber seedlings to increasing amounts of soluble and insoluble phosphates. The optimum level for the insoluble form (rock phosphate) was found to be equivalent to $3\frac{3}{4}$ oz in the planting hole, which confirms the usual recommendation of 4 oz; for the soluble form (superphosphate), on the other hand, the optimum level seemed to be about $1\frac{1}{2}$ oz per planting hole.

Transplanting method for pot experiments. In the pot experiments described above, single seedlings were transplanted from the sand-bed in which they were germinated into each pot. The establishment of these plants in the soil in a condition as uniformly vigorous as possible is obviously desirable in order to keep the 'error' in the experiments as low as possible. In the first pot experiment the average of the coefficients of variation for the various treatments was about 26%. Much of this rather high error could doubtless be accounted for by genetic variation among the seedlings, but observations made during the establishment of seedlings in a subsequent experiment showed that there was a wide variation in the amount of food-reserve used by the seedlings before they were separated from their seeds by accidental rupture of the cotyledon petioles, through which the food-reserve is transferred from the seed to the growing seedlings.

It has already been shown (*Annual Report 1959*) that seedlings grown in sand culture are independent of an external food supply for periods varying between 80 and 150 days (provided presumably that they are not separated from their seed reserve at an early stage after germination). It follows therefore that, in the growing period of a year used in pot experiments, the extent to which seedlings are able to utilise their seed reserve is likely to have a measurable influence on the vigour and size of the plants at harvesting and thus on the 'error' in the experiment.

In a subsequent pot experiment an attempt was made to simulate as far as possible 'natural conditions' during the early growth of the seedlings by a new method of transplanting. The 'natural conditions' under which *Hevea* has evolved, would seem to imply three conditions not specifically observed during routine transplanting. They are: (i) That the seed should be free to move on the soil surface, thus reducing the tendency for the cotyledon petioles to be snapped by wind action; (ii) That the seed should be protected from direct insolation which seems to shrivel up the cotyledon petioles. (iii) Cotyledon petioles should be kept just clear of the wet soil surface to prevent, as far as possible, entry of putrefying organisms into the seed via superficial injuries.

These 'natural' conditions were maintained by planting the seedlings so that the attached seed was kept just clear of the soil surface, and by shading the seed with a leaf. In this way a more uniform 'stand' of seedlings was obtained during the first few months of growth than had been obtained in previous experiments and the observations recorded in *Table 2* below reflect the extent of the improvement obtained.

TABLE 2. EFFECT OF NEW METHOD OF TRANSPLANTING ON UNIFORMITY OF SEEDLING GROWTH

Method of transplanting	Seedlings in the experiment	Seed reserves not completely used	Seeds putrefied	Seedlings needing to be replaced
Routine	120	67	45	12
New	144	11	1	1

Pot experiments with rooted cuttings. A fertiliser experiment to compare the response of PB 86 rooted cuttings to rock phosphate, superphosphate, ammonium phosphate and basic slag at planting hole rates of application, in the presence of lime, was carried out in a Kedah series soil. In all cases the fertilisers were mixed uniformly with the soil, both without and (except where basic slag was applied) with enough limestone to adjust the soil pH from about 4.5 to 6.5. The mean fresh weights in grams per plant after eleven months' growth for the various treatments were as follows:

Treatment					Limed	Unlimed
Control	...	...	...	...	128	221
Basic slag	...	...	...	...	—	204
Ammonium phosphate	...	...	...	...	574	663
Rock phosphate	...	...	...	...	629	808
Superphosphate	...	...	...	...	414	834

Considerable difficulty was experienced in the early stages of this experiment in getting cuttings to 'take' with the 4 oz applications of soluble phosphates, and also with basic slag, but not with rock phosphate. Statistical analysis of the results has, however, shown that there is a definite response to phosphate except for basic slag, and that, as with seedlings, liming depresses the response; the poor response obtained with basic slag, which contains free lime, accords with this finding.

This experiment has not confirmed the expectation that rooted cuttings would provide a more uniform source of experimental material than clonal seeds, since the experimental error was similar to that found previously for seedlings.

Diagnosis of Multiple Nutrient Deficiencies

The 'subtractive technique' described and used by R. A. Webb in West Africa has been modified and used to study a number of typical rubber-growing soils. A description of the way in which the test has been modified was given in the paper 'Inconsistencies in the response of *Hevea brasiliensis* to Phosphatic Fertilisers in Field Trials and in Pot Experiments with Soil' by K. R. Middleton, at the Natural Rubber Research Conference. This technique promises to give a useful method for comparing the levels of the major and minor nutrient elements in Malayan soils, and investigation of such points as test duration and the most suitable part of the plant to harvest is proceeding.

PLANT INVESTIGATIONS

Method of Analysis of Soils and Plant Material

Co-operative analytical work. Leaf samples were exchanged by Dunlop Ltd, Socfin Ltd and the R.R.I.M. and analysed for N, P, K, Ca, Mg, Mn, Cu, Zn and ash. The results showed satisfactory agreement between the three laboratories for most of the determinations undertaken. There were however, some relatively small discrepancies, notably in the determinations of nitrogen and potassium, and further co-operative work has been started to try and account for them.

Investigation of new methods. New methods studied during the year are briefly described below:

1. *Nitrogen by direct nesslerisation.* A method for direct nesslerisation of Kjeldhal digests of leaf samples (thereby eliminating the distillation stage of the determination) has been developed, and is now in routine use.
2. *Determination of boron in aqueous solution.* A recently published method using a new dye (Victoria Violet) was found to work satisfactorily and enabled the use of concentrated sulphuric acid to be eliminated in this determination. Unfortunately it was not sensitive enough to replace our current method.
3. *E.D.T.A. determination of calcium and magnesium.* A new method has been devised in which phosphate-interference is prevented by means of ammonium molybdate. It has been shown to give similar results to those obtained on leaf samples using standard methods and will be published in the January issue of the *Analyst*.
4. *Colorimetric determination of sulphate in plant ash.* A rapid and sensitive procedure for this determination has been worked out based on the use of potassium chromate. It is now being compared with the gravimetric method in current use in these laboratories and if found to be satisfactory will replace it, since the colorimetric method will be more rapid and convenient.
5. *Determination of rubber hydrocarbon.* A volumetric method, sensitive to milligram-amounts of rubber has been devised and its application to the analysis of vegetative parts of the rubber tree is being investigated. The main problems affecting this application are those of extraction of rubber from plant tissue and of interference by other substances soluble in the extract.

The Mineral Composition of Foliage and Latex of Trees in Production

Effect of fertilisers. The detailed investigations of the effects of ammonium sulphate, potassium chloride and rock phosphate applications on the mineral composition of leaves and latex have been continued in the three experiments described in the *Annual Reports 1958 and 1959*. The same main effects of the fertilisers, reported previously, have again been observed in 1960.

The investigation of the effects of trace element applications (manganese, copper and molybdenum) on the nutrient composition of leaves and latex has been continued. Studies on the residual effects of manganese sulphate applications on

leaf and bark scrap manganese content indicate that when manganese deficiency is severe it is necessary to apply two annual applications of manganese sulphate (4 oz) in order to maintain the manganese status of the leaves above a deficiency level. The manganese content of the bark scrap rubber was not increased to a level that would cause the manufactured rubber to have a content above the specified limits of 10 p.p.m., provided that the normal estate practice of washing scrap rubber in water was carried out. The effect of manganese sulphate in increasing the manganese status of the trees was clearly shown by leaf and bark scrap rubber analysis, but not as clearly by latex analysis.

Application of sodium molybdate (6 g per tree) has caused substantial and significant increases in the leaf molybdenum content, whilst only small effects of copper sulphate application on the leaf and latex copper contents have been observed. No effect of copper sulphate (3 oz and 5 oz per tree) on the potassium content of leaves or latex has been observed in the two year period following the first experimental application of copper sulphate. This is in contrast to the reports of a beneficial effect of copper on the absorption of potassium by *Hevea* in Vietnam.

Determining fertiliser requirements. Expanded investigations on the use of leaf and latex analysis for diagnosing fertiliser requirements have proceeded on two main fronts in 1960; firstly there has been a broad study of sampling procedure, collection of data on the nutrient composition of leaves and latex under different field conditions and a study of the effects of fertilisers on leaf and latex nutrient status; and secondly there has been a particular study of the method called 'physiological diagnosis', and the testing of its use in Malaya.

Leaf sampling procedure. Early investigations had indicated that leaves exposed to the sunlight differed in nutrient content from those in the shade, and three easily recognised leaf positions were selected for particular study. The results of these investigations are to be published in a series of articles, beginning in 1961, in the *Journal of the Rubber Research Institute of Malaya*. Marked and consistent differences were observed between the nutrient contents of leaves exposed to light and shaded leaves. There was little variation in the nutrient contents of the leaves exposed to light (i.e. on top of the canopy), despite differences in height, and the least sampling error occurs with these leaves. While shaded leaves from various parts of the tree varied considerably in nutrient composition, this variation was small when only shaded lower leaves and shaded spur leaves were considered. From preliminary results it appears that shaded leaves are more sensitive to the effects of fertilisers and it seems likely that the lower shaded leaves, which are in any case more easily collected than those exposed to light on top of the canopy, will be most suitable for sampling purposes.

A few investigations have been carried out to determine the minimum number of trees that it is necessary to sample, to provide one bulk leaf sample from fields of up to 60 acres, in order to obtain a pre-determined accuracy in the estimation of the leaf nutrient status. The first results from three such studies indicate that the number of trees required is the same for fields, considered to be homogeneous, varying in size from 10 to 60 acres. Further investigations have been carried out but a full assessment of the results is not yet available.

Survey sampling. The survey sampling of leaves and latex from post-war plantings of PB 86, Gl 1, RRIM 501 and Tjir 1 in Selangor, designed to provide basic data for studying the relationships between nutrient status and yield and the nutrient composition of different clones on different soil types, was completed in 1960. Clone PR 107 was included in this survey in 1960. A total of 317 samples of all clones was collected from 9609 acres.

The number of samples collected of each clone in the survey during 1959 and 1960, and the total acreage covered, are shown below.

Clone	PB 86	Gl 1	RRIM 501	Tjir 1	PR 107
No. of samples	175	131	82	24	14
Total no. of samples :	426.	Total acreage :		13,418	

The average sampling unit was 31.5 acres. The leaves sampled were shaded leaves from spurs of limited growth. One bulk sample was collected from thirty trees well distributed over the sampling unit: both leaves and latex were taken from the same trees.

Fertiliser requirements have been assessed on the basis of leaf and latex analysis and recommendations have been given to the estates situated on soils where responses to manuring could be expected. The main requirements indicated have been for nitrogen and phosphate. Very few instances of a requirement for potassium were recorded, most samples showing a high potassium status, particularly in relation to the nitrogen and phosphate status.

Magnesium deficiency symptoms have been commonly observed on PB 86, and on only one occasion in Gl 1. These symptoms only become apparent on mature trees from approximately the fifth month after refoliation, and are found on leaves exposed to full sunlight—normally only those leaves at the top of the canopy.

Manganese deficiency symptoms were also frequently observed, and many instances of incipient manganese deficiency have been revealed by leaf analysis. The symptoms are usually observed in the shaded leaves, low down in the canopy. When the deficiency is severe, symptoms may be found on the exposed leaves also.

Leaves showing an extensive white marginal and tip scorch, sometimes covering one-third of the lamina, have been observed, particularly on PR 107, but also on Gl 1, RRIM 501 and PB 86 (in descending order of frequency) both on inland and coastal soils. Analysis of these leaves has consistently indicated a very low calcium status; otherwise the nutrient status of the leaves was normal. Experiments on the effects of limestone applications have been planned to start in 1961 on trees known to have a low calcium status. The calcium status of trees on clay soils in Selangor is lower than that of trees on inland soils, despite the higher exchangeable calcium content of the former soils. A similar situation has been observed with regard to the calcium status of leguminous covers, *Mikania scandens* and grasses. The survey sampling will be continued in 1961 on selected soil types, and on the same planting material as in 1959 and 1960.

The method of physiological diagnosis. The method called 'physiological diagnosis', for determining the fertiliser requirements of *Hevea*, was first understood as a result of a visit to the Institut des Recherches sur le Caoutchouc au Vietnam

in 1959. The method involves the use of nutrient ratios, rather than of absolute values, and also a comparison of the nutrient content of both leaf and latex. Our objective has been to discover whether this system of diagnosis, which is intended to be valid under all conditions, can be applied without modification to Malayan conditions. If so, the value of the method in Malaya will depend upon the extent to which mineral nutrition is the major factor limiting production in this country.

Modifications to the method, outlined in the following sections, were quickly found to be essential in testing and using the method in Malaya:

1. *Magnesium — leaves.* The physiological diagnosis of magnesium requirements appears reasonable for all clones studied, except Gl 1. It is frequently found with Gl 1 that, for a given area, the diagnosis on latex analysis indicates a marked excess of magnesium, whilst on leaf analysis a requirement is shown; in such cases it is found that the actual leaf magnesium content is not low. In these circumstances of disparity between a leaf and a latex diagnosis, magnesium applications are not recommended.
2. *Manganese — leaves.* Manganese requirements have been indicated by physiological diagnosis in fields where no traces of manganese deficiency symptoms were observed, and where the leaf manganese content was two to three times the level at which symptoms could be expected. In view of the high cost of manganese sulphate fertiliser, the lack of a full assessment of the effect of manganese sulphate on yield, the possibility of inducing manganese toxicity and the dangers of increasing to an excessive degree the manganese content of the bark scrap rubber, extreme care should be taken when diagnosing manganese deficiency. Physiological diagnosis cannot be taken as a reliable guide in this matter. In our experience the condition of the trees in the field and the leaf manganese content should both be used to judge the severity of the deficiency and only when it is severe should manganese sulphate be applied.
3. *Copper — leaves.* The general level of leaf copper content in Malaya was found to be lower than that reported in Vietnam. Thus a diagnosis based on Vietnam data almost invariably indicated a copper deficiency. As no beneficial effects on growth, yield or nutrient uptake have been observed in two experiments involving copper sulphate, it is considered that copper sulphate cannot be recommended on a routine advisory level on the basis of 'physiological diagnosis'. Three further experiments to test the effectiveness of copper applications are in progress.
4. *Sodium — leaves.* The diagnosis for magnesium and manganese requirements, based on leaf analysis only, is made from a consideration of three ratios involving magnesium, manganese and sodium. The leaf sodium content of *Hevea* in Malaya has been found to be much lower than in Vietnam, and in using the diagnostic method a large requirement for sodium is indicated, with an excess of magnesium and manganese, when in fact the contents of the latter two are at extremely low levels at which deficiency symptoms would be expected. The marked variation in leaf sodium content thus invalidates an assessment of the requirements for magnesium and manganese based on leaf analysis only.

5. *Sulphur — leaves.* There was little variation between the leaf sulphur contents of clones studied at different times of the year, and under different conditions, when compared for example with the magnesium or phosphorus contents. No marked effects of fertilisers containing sulphur on the leaf sulphur content have been recorded. The value of a diagnosis of the sulphur requirement is problematical, and definite evidence of responses to the application of sulphur as a nutrient is required before sulphur assumes importance.
6. *Latex analysis.* The value of latex analysis for determining the nutrient requirements of the tree is doubtful, although it may yet be of value in matters concerning yield stimulation, latex instability or tree injection. In assessing nutrient requirement, latex analysis combined with leaf analysis, as in the diagnostic method, frequently indicates requirements for nutrients when the leaves already have a high content of those nutrients. Conclusive evidence to show the interdependence of leaf and latex nutrient contents is required before data on leaf and latex can be combined to give a useful indication of the nutrient requirements of the tree. To date, our investigations indicate that the relationships between the leaf and latex contents of nitrogen, phosphorus and potassium respectively, are of little significance; the correlation coefficients between the leaf and latex contents of nitrogen, phosphorus and potassium, in three experiments are shown below.

		<i>Leaf nitrogen to latex nitrogen</i>	<i>Leaf phosphorus to latex phosphorus</i>	<i>Leaf potassium to latex potassium</i>
Experiment 1	...	— 0.185*	+ 0.078	+ 0.274**
Experiment 2	...	+ 0.045	— 0.161**	+ 0.138*
Experiment 3	...	+ 0.379***	+ 0.220*	+ 0.383***

Application of physiological diagnosis in fertiliser trials. Twelve pilot trials, based on a task plot design, were started in 1960 to investigate both the validity of the method of physiological diagnosis and also the effectiveness of fertiliser applications to mature rubber. Areas chosen on inland soils had all been manured during immaturity. Three trials were terminated in October owing principally to the need for retasking in the trial areas. Treatments based on the results of leaf and latex analysis, were compared with normal fertiliser applications.

The yield data available for the first nine months after the experimental application of fertilisers, show no significant increases in yield. This is in contrast to the situation reported in Vietnam, where substantial yield increases were observed six months after fertiliser applications based on physiological diagnosis.

Of particular interest in these trials has been the comparison of ammonium phosphate and rock phosphate. With both fertilisers, increases in the leaf phosphorus content have been observed 7–10 weeks after application during the wintering period, and the effects of the two phosphatic fertilisers were very similar.

This relatively rapid effect of rock phosphate on the leaf phosphorus content is in contrast to the very slow effect, taking several months, of rock phosphate applied after refoliation, as previously reported. Further investigations are required into the effects of time of application of rock phosphate (in relation to wintering and refoliation) on growth, yield and absorption of phosphorus.

A further eight pilot trials were started during 1960 on areas investigated in the course of the survey leaf and latex sampling. A total of seventeen experiments are now being carried out, nine on inland soil types and eight on coastal alluvial soils, all in Selangor. A new series of approximately nine trials are planned to start during the wintering period 1961, seven on inland soil types and two on coastal alluvial soils.

Injection experiments. Four simple exploratory experiments were started in 1960 to study the effects of injection into the stem wood of ammonium phosphate, magnesium sulphate and copper sulphate on the latex yield and nutrient content of the latex and leaves. No yield responses have been recorded. Increases of 30% in the latex phosphorus content were observed in two experiments, five weeks after injection of 30 g per tree of ammonium phosphate on clones Gl 1 and RRIM 501. The increased levels of phosphorus were maintained for three to four months. Similarly, 30% increases in the latex magnesium content of Tjir 16 were recorded six to seven weeks after injection of 30 g magnesium sulphate per tree; this effect was maintained for the following four months. Only slight damage has been observed following injection. Microscopic examination of the wood revealed only slight damage to the xylem vessels, three months after injection, even in the stained (wound barrier) layer. A study of the distribution of phosphate in the wood following injection indicated that the phosphate had only slightly penetrated the wood, with no concentration of phosphate either in the outer wood or in the bark.

Preliminary studies on the most efficient positioning of the injection holes, to obtain maximal increases in the latex phosphorus content, indicate that injection by means of holes close to the tapping panel is the best method. Further work is required on the positioning and slope of the injection holes, and the method of protection of the cambium.

POT SAND-CULTURE EXPERIMENTS

Effect of Macro- and Micro-nutrients on the Growth and Composition of Rubber Seedlings

No further work has been carried out on this subject following the completion of the experiments on boron nutrition and on the requirements of *Hevea* for nutrient elements at different stages of growth.

Nutrient Deficiency Symptoms in Hevea and Leguminous Creeping Cover Plants

Demonstrations of nutrient deficiency symptoms shown by *Hevea*, *Pueraria phaseoloides*, *Centrosema pubescens* and *Calopogonium mucunoides* have been maintained throughout the year. They were of particular interest to visitors during the Natural Rubber Research Conference.

ADVISORY

The staff made ninety-four advisory visits to estates, many of which were in company with an officer of the Estates Advisory Service. A considerable amount of advice was also given by letters or by interviews at the Institute. A large proportion of the enquiries received concerned fertilisers and herbicides. Compound fertilisers containing phosphate in the water-soluble form are being imported into the country in increasing quantities, and the Division is maintaining an interest in the performance of these fertilisers in the field. Lectures were given by members of the staff to Senior Estate Conductors, Rubber Instructors and students from the College of Agriculture attending courses at the R.R.I. Experiment Station, and Incorporated Society of Planters branches in Kota Bharu, Lower Perak, Malacca, Central and South Johore and Pahang Districts.

The usual assistance was given to the Technical Education Scheme of the Incorporated Society of Planters by setting questions and marking papers for the Soils Section of the Agricultural Science Examination held in February and August.

G. A. WATSON
Head of Soils Division

Botanical Division

Dr C. F. Arlett was appointed as Microgeneticist with effect from 1 January 1960 and has taken charge of the testing station for *Dothidella* resistance in Trinidad.

Mr J. B. Gomez joined the staff on 12 September to take charge of the anatomical work and Mr S. K. Majumder on 3 October to work on cytogenetical problems.

Mr T. V. Vaidyanathan retired on medical grounds with effect from 28 September.

RESEARCH

BREEDING AND SELECTION

Hand Pollination

The hand pollination programme followed the same general lines as in 1959 and resulted in one large family, several exploratory families and some experimental crosses. A total of 46,587 pollinations were made between 15 February and 12 April. The results are shown in *Table 3*.

The large family chosen was RRIM 628 $\times$ RRIM 612; 6,107 pollinations were made with RRIM 628 as the female parent and 6,503 with RRIM 612 as the female parent. At the seventh week from pollination no developing fruit remained on the trees of RRIM 612 while 3.8% of the pollinated flowers on the trees of RRIM 628 were bearing immature fruit. Because of this loss another large family (RRIM 501 $\times$ 44/553) was chosen. This cross had been made previously in 1948 and the results have been promising. One of the clones made from the cross is the newly selected RRIM 701. 10,175 pollinations were made with RRIM 501 as the female parent and 576 with 44/553 as the female parent.

7,414 exploratory crosses were made between clones RRIM 513, RRIM 605, RRIM 701, Ch 26 and PB 28/59. Where possible, reciprocal crosses were made.

The inbreeding programme was continued by selfing RRIM 513 (4,791 pollinations) and by selfing S1 seedlings of RRIM 605 (1,286 pollinations) and Lun N (314 pollinations). In addition an experiment was carried out to test the relative fertility of self, sib, half-sib, back- and out-crosses on female flowers of RRIM 501. Sets of three trees of RRIM 501 were chosen which came into flower at the same time and were growing close to each other under similar environmental conditions. A pollinator was allocated to each tree and carried out as many pollinations as possible with pollen of the following clones:

RRIM 501 (Pil A44 $\times$ Lun N)	...	selfing
RRIM 509 (Pil A44 $\times$ Lun N)	...	sibbing
RRIM 513 (Pil B16 $\times$ Pil A44)	...	half sibbing
Pil A44	...	back crossing
PR 107	...	out crossing

TABLE 3. RESULTS OF THE 1960 HAND POLLINATION PROGRAMME

Families	No. of pollinations	No. of fruits harvested	% of pollination success	No. of seeds planted	Mean wt of seeds, grams	No. of seeds germinated	% of germination success
1. RRIM 612 × RRIM 628	6503	—	—	—	—	—	—
2. RRIM 628 × RRIM 612	6107	214	3.5	648	3.2	418	65
3. RRIM 501 × 44/553	10175	340	3.3	1005	3.8	71	7
4. 44/553 × RRIM 501	576	18	3.1	60	4.7	28	47
5. Ch 26 × RRIM 513	662	61	9.2	180	3.5	55	31
6. RRIM 513 × Ch 26	523	19	3.6	59	5.5	54	92
7. Ch 26 × PB 28/59	1278	90	7.0	267	3.9	122	46
8. RRIM 513 × PB 28/59	1331	58	4.4	167	5.3	137	82
9. RRIM 513 × RRIM 605	1044	45	4.3	133	5.3	107	80
10. RRIM 513 × RRIM 701	2110	78	3.7	246	5.2	196	80
11. PB 28/59 × RRIM 701	291	4	1.4	13	5.1	9	69
12. PB 28/59 × RRIM 605	175	4	2.3	12	5.4	10	83
13. RRIM 513 selfed	4791	178	3.7	522	5.4	377	72
14. Lun N S ₁ seedlings selfed	314	—	—	—	—	—	—
15. RRIM 605 S ₁ seedlings selfed	1286	38	3.0	116	4.3	96	82
16. RRIM 501 selfed	1657	62	3.7	178	4.6	128	72
17. RRIM 501 × RRIM 509	1620	50	3.1	153	4.5	142	93
18. RRIM 501 × RRIM 513	1618	70	4.3	207	4.6	155	75
19. RRIM 501 × P11 A44	1647	61	3.7	181	4.6	146	81
20. RRIM 501 × PR 107	1628	62	3.8	183	4.5	134	73
21. PB 86 × <i>H. benthamiana</i>	377	19	5.0	58	5.3	57	98
22. GT 1 × <i>H. benthamiana</i>	345	10	2.9	30	3.7	28	93
23. Peruvian <i>H. brasiliensis</i> 3 × RRIM 501	529	—	—	—	—	—	—
Total or mean	46587	1481	3.2	4418		2470	56

In order to eliminate possible differences in the success of pollinations carried out at different times during the morning, each pollinator carried pollen of all five clones. The female flowers of consecutive inflorescences were pollinated with different pollen. Each morning the pollen was used in a different order. The results of the 8,170 pollinations which were made are given in *Tables 4 and 5*.

The results have not yet been fully examined, but it is clear from the tables that there is no difference in the fertility of the crosses made. There are no differences between the results of the three pollinators in the percentage of fruit harvested but there is a clear difference between their results in the counts of developing fruit one week after pollination. This is being investigated. The pollinators differed also in the number of pollinations they made per day.

Two families, PB 86 $\times$ *H. benthamiana* (377 pollinations) and GT 1 $\times$ *H. benthamiana* (345 pollinations) were produced for work concerned with rooting of cuttings.

The cross Peruvian *H. brasiliensis* 3 $\times$ RRIM 501, from which no mature fruits were harvested after 525 pollinations in 1959, was repeated in 1960. All developing fruits had dropped off by the fifth week after pollination and no mature fruits resulted from the 529 pollinations made.

The percentage success of the hand pollinations in 1960 (3.2%) was less than half of that in 1959 (7.4%) and slightly less than the mean of all hand pollinations carried out at the R.R.I. between 1928 and 1959 (4.8%), but the number of hand pollinations carried out was very much higher than in any previous year. The only crosses which resulted in a high percentage success were Ch 26 $\times$ RRIM 513 and Ch 26 $\times$ PB 28/59 (9.2% and 7.0% respectively). The seeds of Ch 26 were light, however, and the germination was very poor. The selfing of RRIM 513 and S₁ RRIM 605 seedlings is shown to be as successful as out crossing. Only 314 pollinations were made in selfing S₁ Lun N seedlings and all developing fruits had dropped off by the seventh week.

Developing fruits were counted one week after pollination and thereafter at fortnightly intervals. There was no marked difference in loss of immature fruit between the families except for the three crosses which failed completely. After the ninth week no loss occurred except for a few cases of squirrel damage and branch breakage. The results of the counts are given in *Table 6*.

TABLE 6. LOSS OF FRUIT DURING MATURATION

No. of hand pollinations	% success in weeks after pollination					% success at harvest
	1	3	5	7	9	
46,587	71.5	27.8	7.0	3.4	3.3	3.2

All seeds were weighed before being placed in peat pots for germination.

The germination of the seeds varied considerably. The poorest germination occurred in the seeds of RRIM 501 $\times$ 44/553 of which only 7% germinated. The mean weight of these seeds was 3.8 grams compared with 4.5 or 4.6 grams

for the RRIM 501 seeds in the inbreeding experiment where germination averaged 79%. The two crosses in which Ch 26 was the female parent (Ch 26 $\times$ RRIM 513 and Ch 26 $\times$ PB 28/59) and which gave the highest percentage of pollination success (9.2% and 7.0%) also produced light seed with poor germination (31% and 46%). The percentage germination in all the other crosses except 44/553 $\times$ RRIM 501 (47%) was average or high.

The 1960 hand pollinated seedlings have been planted out in a specially prepared nursery.

Seedling Families

Field 58A. The hand pollinated seedlings resulting from the 1952 programme were brought into tapping in May.

Field 20B. The hand pollinated seedlings from the 1958 programme and those of the 1956 programme which were not planted out in Field 61B were planted out in Field 20B at the end of the year.

Fields 56A and 52E(ii). The clones made from the 1951 hand pollinated seedlings were brought into tapping in July.

Field 64. At the end of the year a small scale clones trial was being established in Field 64. It includes clones made from the seedlings resulting from the 1955, 1956, 1957 and 1958 programmes. RRIM 605 is present as a control.

Study of Collections and Introduction of Hevea Species

Field 55A. The small scale trial of clones made from seedlings imported in 1951 was brought into tapping in April. These clones include *H. spruceana* from Arredores de Manaos, *H. benthamiana* from Rio Negro and *H. brasiliensis* from Peru and Brazil. Yields are very poor.

Field 55B. The small scale trial of clones from the imported seedling collection and from the species crosses *H. brasiliensis* $\times$ *H. spruceana* made in 1951 was brought into tapping in October.

A successful import was made of I.A.N. clones ('6000 series', second out crosses of F 4542 *Hevea benthamiana* with oriental *Hevea brasiliensis*) from the R.R.I. of Ceylon.

Selection of Clones from Small Scale Trials

The following RRIM 700 series clones have been selected for large scale testing at the R.R.I. Experiment Station and on estates:

RRIM 700 (44/553* $\times$ RRIM 501)	RRIM 705 (RRIM 632 $\times$ RRIM 500)
RRIM 701 (44/553* $\times$ RRIM 501)	RRIM 706 (RRIM 632 $\times$ RRIM 500)
RRIM 702 (44/553* $\times$ RRIM 501)	RRIM 707 (RRIM 632 $\times$ RRIM 501)
RRIM 703 (RRIM 600 $\times$ RRIM 500)	RRIM 708 (RRIM 623 $\times$ RRIM 501)
RRIM 704 (RRIM 600 $\times$ RRIM 500)	

* Clone 44/553 = Tjir 1 $\times$ Pil B84

Large Scale Trials of Selected Planting Material

Pre-war trials. A limited number of RRIM 500 series clones trials is still under recording; tapping is on a high cut or on two cuts (see under 'Tapping Experiments').

Post-war trials. The position at the end of 1960 was as shown in Table 7.

TABLE 7. NUMBER OF POST-WAR TRIALS

Trials	Mature in December 1960		Immature in December 1960	
	No. of trials	Total acreage	No. of trials	Total acreage
Distributed block trials (RRIM 600 series)	19	96		
Complete (RRIM 600 series)	23	443	10	154
500 series and new clones	8	108	1	13
Foreign exchange clones			6	467
Clonal seedling			3	89
Clone-cum-tapping experiments			2	95
RRIM 700 series			2	78
Other field experiments			2	21
<i>Total</i>	50	647	26	917

This table includes ten trials at the R.R.I. Experiment Station and a number of observation areas. A total of about 230 clones are being tested in these trials.

Yield recording continued in the mature trials; all trials were visited twice a year by field assistants in order to check on recording, to take girth and bark measurements and to count wind damage and brown bast cases.

A further report on the RRIM 600 series trials at the Experiment Station was published in *Planters' Bulletin* 46, January 1960. Some results of estate trials and a description of the recommended clones were given in *Planters' Bulletin* 48, May 1960.

The yield of clone RRIM 600 in the large scale trial at the R.R.I. Experiment Station increased further in the fifth year of tapping. It is now the highest yielding clone in this series, but the bulging panel and branching habit cause concern.

Clone RRIM 628 continued its high yield; girth increment is poor. The yield of clone RRIM 623 dropped in the second year in a trial on coastal clay.

One trial on coastal clay was completely lost through wind damage during the year. In another trial about half of the plots had to be abandoned after an exceptionally heavy storm; clones RRIM 501, 606, 613, 614, 615 and 616 were the most heavily affected, while clones RRIM 607 and 612 appeared to be particularly resistant to wind.

In the trials at the Experiment Station a special recording of 'late dripping' (giving lower grades of rubber) was started. The 'late dripping' yield expressed as percentage of the total yield of each clone varied from about 6% (RRIM 600, 623) to over 20% (RRIM 621, 627).

Results of testing of clonal latices by the Chemical Division during 1959-1960 are summarised in *Table 8*.

TABLE 8. RESULTS OF TESTS OF CLONAL LATICES

Clone	d.r.c.	Mg/P (field latex)	N/K (field latex)	Mechanical stability of concentrate
RRIM 501	*	— —	*	+
RRIM 526	— —	*	*	+
RRIM 527	—	*	*	—
RRIM 600	*	*	*	—
RRIM 603	*	+	*	*
RRIM 605	+	+	+	*
RRIM 606	*	*	*	+
RRIM 607	++	*	+	+
RRIM 609	—	— —	*	+
RRIM 610	*	+	+	—
RRIM 612	+	—	*	+
RRIM 614	*	*	*	+
RRIM 621	— —	—	—	*
RRIM 623	++	*	*	+
RRIM 628	*	*	*	+
PR 107	++	—	*	—
LCB 1320	—	++	—	*
PB 86	*	++	*	*
PB 5/37	— —	++	*	—
PB 5/51	*	—	*	+
PB 5/63	—	*	*	+

KEY

d.r.c.	Mg/P
— — Low (30.6%)	— — Low (0.40)
— Below average (30.6 – 32.3%)	— Below average (0.40 – 0.50)
* Average (32.3 – 35.7%)	* Average (0.50 – 0.80)
+ Above average (35.7 – 37.4%)	+ Above average (0.80 – 1.00)
++ High (37.4%)	++ High (1.00)
N/K	Mechanical stability
— Low (< 1.30)	— Poor (< 400 TMS)
* Average (1.30 – 1.55)	* Marginal (400 – 600 TMS)
+ High (> 1.55)	+ (> 600 TMS)

Instability of latex concentrate seems to be connected with a high Mg/P or with high Cu in the latex. Clones with low d.r.c. usually have a low N/K ratio in the latex.

Girth measurements in the foreign exchange clone trials 2–3 years after budding confirm the vigorous growth of the following clones:

RRIM 603, 615, 623, 632, 636, 638.

RRIC 7, 14.

PR 252, AVROS 1279, 1518.

The exceptional good vigour of clone RRIM 701 (= ES 1) is confirmed in the Exchange Clones Trial at R.R.I. Experiment Station; the mean girth three years after budding was 12.7 inches against 11.2 inches for RRIM 501.

New clone trials. In 1960 two clone-cum-tapping experiments were budded on co-operating estates; they contain 16 of the most promising RRIM and foreign clones. Design is such that comparison of two different tapping systems will be possible.

A programme of testing nine new RRIM 700 series clones, selected from small scale clone trials on the performance of four tapping years, was initiated; one trial was budded at R.R.I.E.S. and one on an estate. During 1961 five more trials will be budded. These trials are of a uniform design and contain RRIM 700–708, a number of new Prang Besar and Chemara selections and PB 86 and RRIM 605 as controls.

Clonal seedling trials. Girth measurements were taken in two immature clonal seedling trials. In one trial there is a suggestion that Tjir 1 selfed seedlings are less vigorous than Tjir 1 seed from a polyclonal seed garden. Illegitimate seedlings of clones RRIM 600, 603 and 623 appear to be more vigorous than those of clone RRIM 501 in the second trial. A third trial was planted towards the end of 1960. It contains five families from seed gardens, six selfed families and a budded control. One more clonal seedling trial will be planted in 1961.

High density trial. In this experiment seeds have been planted at very high densities, varying from 227 up to 3632 seeds per acre. There will be two methods of thinning out; one based on girth and the second based on yield prediction methods. This experiment was planted in December 1960 and is expected to give interesting information on competition, variability and yield prediction.

Cytology

A cytological laboratory has been established and a new appointment was made towards the end of 1960. The work was limited to the establishment of laboratory techniques.

Interaction Between Dothidella ulei and Hevea

An R.R.I.M. unit has been established in Trinidad with Dr C. F. Arlett in charge of investigations on *Dothidella ulei*, the causal organism of South American leaf blight of *Hevea*.

Work on culturing of the fungus has commenced. Nurseries have been made available. The first shipment of *Hevea* budwood from Malaya failed through exposure to low temperatures during transport.

PROPAGATION AND PLANTING METHODS

Crown Budding

Part of the established crown budding experiment reached tappable size during 1960. The trees were budded at normal height in December 1951 and at a height of six feet during 1954.

The clones used are Tjir 1 (vigorous, good yield); LCB 870 (vigorous, low yield, used for crown budding elsewhere because of resistance to *Oidium*); BD 5 (poor vigour but good yield capacity, in suitable areas) and a clone of *Hevea spruceana* (vigorous; very low yield).

Each of these clones was used as scion and top budded with the same four clones in sub-plots. There are many top budding failures especially on clone BD 5.

Girth measurements taken in August 1960 at fifteen inches above the union are summarised in Table 9.

TABLE 9. MEAN GIRTH IN INCHES

Crown	Trunk				
	<i>Hevea spruceana</i>	LCB 870	Tjir 1	BD 5	Mean
<i>H. spruceana</i>	24.9	22.8	22.8	21.2	22.8
LCB 870	25.5	26.9	24.8	25.4	25.7
Tjir 1	26.2	26.3	24.2	24.9	25.4
BD 5	16.9	18.4	16.4	16.6	17.1
Mean	23.4	23.6	22.1	22.0	

Minimum 5% significant difference for crown means with same trunk = ± 2.07

Minimum 5% significant difference for trunk means with same crown = ± 4.38

The analysis shows that the crown has a very highly significant effect on growth (mainly owing to retarding effect of BD 5), but the effect of the trunk is not established. An analysis of the girth increments for 1958-59 showed inferior girth increment of Tjir 1 trunks.

A number of *Dothidella*-resistant clones have been top-budded on scions of clones RRIM 501, PB 86 and Tjir 1 in a second crown budding experiment. Supplying was still in progress at the end of the year.

Stock/Scion Relationships

The results of experiments, set up before the war, have been analysed and are to be reported in the *Journal of the Rubber Research Institute of Malaya*.

Experiment I, Field 1A. This consisted of three acres planted in 1934 with three families of illegitimate clonal seedlings (AVROS 49, AVROS 157 and PB 25). These were budded in December 1935 with BD 5, AVROS 157, AVROS 49 and PB 25 in all possible combinations on a tree plot basis. Yield records from 1947 to 1952 are available. Stock means do not differ significantly when averaging over the four scions. With three of the scions there is no evidence of stock influence on

yield but with AVROS 49 scion, PB 25 stock is associated with a significantly lower yield than AVROS 157 stock. Analysis of 1947 girths indicates a significant stock as well as a scion effect. Seedlings of the most vigorous scion clone (AVROS 157) appeared to be the best stock material. For girths taken in 1940, no stock effect is evident.

Experiment II, Field 4C. This consisted of two and a half acres planted in 1930 with 'twinned' seedlings (illegitimate Pil A 44 and Pil B 58). One of each pair was used as stock for clones Tjir 1, PB 186, BD 5 and D 65. Unbudded pairs of twins were used as controls.

Yield records from 1938 to 1956 are available. Highly significant positive correlations are found between pairs of unbudded twins, but correlations between budded and unbudded members of twins are less well marked. Significant correlations for yield seem to occur more frequently in those years when the tapping cut is on or near the stock. Significant girth correlations for Tjir 1 and for Pil D 65 buddings with the twins of their stocks occur in several years, but with PB 186 and BD 5 the girth correlation does not reach significance in any year.

Experiment III, Field 22B. Some progress has also been made in analysing the results of another twinned seedling experiment set up in 1930-31, in a ten-acre field. Five illegitimate seedling families of clone Pil A 44, SR 9, PB 24, PB 20 and mixed seed from Malayan American Plantation clones (MAP) were used as stocks for clones AVROS 50, Pil B 84 and PB 186. Unbudded twins were used as controls. Highly significant positive correlations between unbudded pairs of twins are found in all years. Significant correlations, for girth and for yield, between budded and unbudded pairs are found with clone PB 186 on MAP and Pil A 44 seedlings and with clone Pil B 84 on PB 20 seedlings. In addition, significant correlations are found with clone AVROS 50 on SR 9 seedlings for yield only, and with clone Pil B 84 on SR 9 seedlings for girth only. Considering budded trees on their own, stock effects are established with clone PB 186 as scion, but not with the other clones; these findings are, however, confounded with block effects.

Current investigations. It was intended that a small experiment on stock-scion relationships would be set up in 1960, using rooted cuttings as clonal rootstocks. Owing to initial difficulties in budding this type of material, this experiment was postponed, and in its place an experiment comparing rooted cuttings of GT 1, PB 86 and FX 652, and seedling stumps budded with the same three clones, was set up in Field 64 D.

It is hoped to set up a small stock-scion experiment early in 1961, using four clones in all combinations, for growth analysis over the first two years. A larger, long term trial will be set up as soon as suitable land and material is available.

One other stock-scion experiment is in progress. This was planted in 1948-49 to compare unselected *Hevea brasiliensis* with illegitimate *H. spruceana* seedlings as stocks for four clones, Gl 1, Tjir 1, RRIM 501 and PB 86. The layout consists of three randomised blocks, with scions as main plots and stocks as sub-plots in alternate rows. The area has now been in tapping for three years. Table 10 shows mean yields per tree per tapping for the period July 1957 to June 1960, and the girth measurements at 60 in. above the union in June 1960.

TABLE 10. MEAN GIRTHS AND YIELDS

Seedling stocks	Measurement	Scion			
		GI 1	Tjir 1	RRIM 501	PB 86
<i>H. brasiliensis</i>	mean girth (in.)	20.1	23.9	22.4	18.8
	yield, g/tree/tapping	17.7	15.1	33.8	20.7
<i>H. spruceana</i>	mean girth (in.)	21.2	23.3	22.8	21.7
	yield, g/tree/tapping	15.6	16.2	31.2	16.7

There is a highly significant ($P < 0.01$) effect of scions on yield and on girth, but with neither measurement is a stock effect established. With PB 86 scion, the difference between stock girths almost reaches significant level.

Vegetative Propagation of Hevea

Work on rooting leafy cuttings of clones of *Hevea brasiliensis* continued, with the emphasis on improving the technique adopted during 1959 with particular regard to hardening-off and establishment in the field.

A small mist propagation enclosure was built at the Institute, together with facilities for potting and hardening-off.

To accommodate more cuttings, 6 frames each with 10 MacPenny nozzles and measuring 35 ft $\times$ 5 ft were completed in August at the Experiment Station. Sufficient water under pressure is supplied through a 1 H.P. electric pump. Nutrient solution is metered when required from a tank which supplies all the frames. Two hardening-off frames were constructed in which the duration of spray over the newly potted rooted cuttings is regulated as required by an interval timer. Shade on these frames can be removed as hardening proceeds.

It is possible, with the increased frame area, to accommodate over 4,000 cuttings at one time. More budwood particularly of clones PB 86, GT 1 and RRIM 501 was made available at the Experiment Station and cut back to provide source material.

During the year 9,380 leafy cuttings were taken, of which 6,560 rooted. These included 3,474 PB 86 cuttings taken on 43 different days, 80.3% of which rooted, and 1,305 GT 1 cuttings taken on 23 days of which 84% rooted. Fermate powder was applied to the base of the cuttings.

Further evidence was collected showing the importance of this application of Fermate (Ferric dimethyldithiocarbamate), which appears to promote root formation as well as possessing fungicidal activity. A more concentrated powder (up to 87.5% of active ingredient) was found to effect better and speedier rooting with a number of clones than the 20% powder formerly used. Tests on the rooting ability of different clones were continued; PR 107 was found to be in the same easy rooting category as PB 86, GT 1 and many *H. brasiliensis* $\times$ *H. benthamiana* hybrids.

Rooted PB 86 cuttings were supplied for a pot culture manurial experiment and as planting material for growth analysis in both pot and field culture. Observation plots of PB 86 and GT 1 cuttings have been established on estates.

A small area in Field 17 at the R.R.I. Experiment Station was planted with cuttings of a number of clones for later testing for root disease resistance. More clonal cuttings for root disease studies were planted in Field 42, and, also in this field, observation plots of PB 86 and GT 1.

Approximately 3,000 clonal cuttings were successfully established at close spacing in a nursery to add to the 500 planted in 1959.

An experiment, five acres in extent, was planted in November in Field 64 D to compare cuttings with budded stumps using clones GT 1, PB 86 and FX 652 (a hybrid). The similar, but smaller scale experiment planted in 1959 in Field 64 C required some supplies both of cuttings and budded stumps. The growth of the PB 86 and GT 1 cuttings is in general quite as rapid as the budded stumps, but to prevent the cuttings from being rocked at soil level by the wind, it was necessary to stake some of them after six months growth. So far, however, no cuttings in the field or in the nursery have been lost by uprooting.

The rooting habit observed in the nursery shows that with leafy cuttings there is strong formation of laterals. However, these cuttings were planted in a shallow soil and in baskets through which lateral root formation is encouraged. During the year a change-over was made from baskets to flat perforated polythene bags 19 in. long $\times$ 8 in. wide $\times$ 0.06 mm thick which it is hoped will encourage deeper rooting; they have the advantage over baskets of permitting the cuttings to be held longer if necessary until planting conditions permit, and also facilitate hardening-off.

With a view to planting stock/scion experiments using vegetatively propagated clonal rootstocks, budgrafting was attempted on 8–15 month old cuttings. Although the graft united well, at first the stocks died after cutting back. Later successful emergence of the scion bud was achieved by ring barking above the bud and cutting back the stock 3–4 ft above the ground, thus retaining some leaves.

Cuttings were planted into a nursery for a short term stock-scion experiment and will be budded during 1961.

Budgrafting small rootstocks. A visit was made to North Borneo where the Department of Agriculture is experimenting with budding 4–5 month old stocks using green budwood, with the object of obtaining, within one year of sowing the seed for the root-stocks, small stumped buddings which can be distributed to smallholders as alternative planting material to clonal seedling stumps.

To supplement the work done in Borneo and test the method under Malayan conditions, an experiment was begun in Field 14 D. Stocks will be budded at eight intervals between 3 and 12 months of age using clones PB 86 and RRIM 501. Budding successes will be recorded and scion growth measured.

Planting Systems

The field in which our oldest density of planting experiment was conducted was replanted during 1960.

The experiment was carried out on clone AVROS 50 using six densities, from 48 to 435 trees per acre. Five of these were square systems, the other was triangular.

Results of this experiment were published in *Planters' Bulletin* 22. A detailed account is being completed for publication in the *Journal of the Rubber Research Institute of Malaya*.

In a more recent experiment a comparison is made between hedge planting systems and more conventional systems. Eleven planting systems are compared ranging from 20 ft $\times$ 12 ft to 80 ft $\times$ 2 $\frac{1}{4}$ ft with four clones: RRIM 513, 527, LCB 1320 and Tjir 1.

Two thinning procedures have been superimposed, one to a constant number for all densities and the second in proportion to planting density.

The July 1960 girth measurements are summarised in *Table 11*.

TABLE 11. MEAN GIRTHS (INCHES) OF TREES IN HEDGE PLANTING EXPERIMENT, JULY 1960

Planting system	Original density	Density after thinning in 1956	Mean girth	Density after thinning in 1956	Mean girth
30 $\times$ 8	182	145	21.3	145	20.9
50 $\times$ 6	145	125	22.1	145	21.3
50 $\times$ 4 $\frac{1}{2}$	194	155	20.3	145	21.4
50 $\times$ 3 $\frac{1}{2}$	249	185	20.2	145	22.2
65 $\times$ 4 $\frac{1}{2}$	149	125	21.0	145	20.5
65 $\times$ 3 $\frac{1}{2}$	192	155	20.2	145	21.4
65 $\times$ 2 $\frac{3}{4}$	244	185	19.6	145	21.5
20 $\times$ 12	182	145	21.1	145	22.5
80 $\times$ 3 $\frac{1}{2}$	156	125	19.4	145	19.1
80 $\times$ 2 $\frac{3}{4}$	198	155	17.9	145	20.4
80 $\times$ 2 $\frac{1}{4}$	242	185	17.3	145	19.0

Wind Damage Investigations

a. *Timber testing.* Trees of AVROS 50, planted as budded stumps 30 years previously, had been grown at different densities. Five trees were sampled from three densities representing the extremes and an intermediate. Specimens of timber were subjected to static bending tests at the Timber Research Laboratory of the Forest Research Institute, Kepong, where facilities were provided by the kind co-operation of the Chief Research Officer and the Timber Research Officer, whose assistance is gratefully acknowledged. The method has been explained on pages 58 and 59 of the *Annual Report 1959*.

In addition to the tests on the timber specimens, the girths, height and fresh weights of the above-ground parts of trees were determined. A summary of the results is given in *Table 12*. The girth, total weight and weight of foliage per tree decline with increasing density; although the total basal area, quantity of

timber and weight of foliage per acre all increase with density (c.f. yield per tree and per acre). Consistent effects of planting density on specific gravity of the timber were not found.

TABLE 12. MEAN DATA PER TREE FOR THREE DENSITIES OF PLANTING

Density of planting (trees per acre)	48	125	435
Girth at 60 inches (inches)	49.6	36.6	25.2
Total height (feet)	87.3	92.1	83.6
Total fresh weight (pounds)	6,109	2,492	1,162
Foliage, fresh weight (pounds)	100	34	23
Number of timber samples	36.6	17.6	7.0
Specific gravity of timber at test	1.045	1.024	1.078
'Basic' specific gravity of timber	0.604	0.597	0.575
Modulus of rupture (lb. sq. in.)	7,522	7,390	8,447

The different numbers of specimens obtainable from the trees of markedly different sizes complicated the analysis, because positional effects were confounded with treatments. Specimens were taken from all trees at two heights: (a) 30 to 60 inches and (b) 60 to 90 inches above the union. The specimens were $30 \times 2 \times 2$ inches and in most trees, four specimens free from defect were obtainable from around the centre of the tree at each height. From the smallest trees grown at 435 trees per acre, only these 'inner' specimens were obtainable. In the other trees a further four specimens were obtainable at each height from positions immediately adjacent to and outside the inner specimens. In the largest trees, grown at 48 per acre, even more specimens were obtainable from positions outside those mentioned above.

The modulus of rupture was compared for specimens taken (i) from different positions within trees grown at the same density and (ii) from the same positions within trees grown at different densities. A general tendency was found for the upper specimens to be stronger than the lower. This tendency was most marked in the larger trees. Where two or more concentric rings of specimens within trees grown at the same density could be compared, the outer specimens were found to be stronger than the inner. However, the lower, outermost specimens of the largest trees were weaker and this has been attributed to irregularities in the timber caused by tapping. Specimens from the smallest trees grown at the highest density had a higher mean modulus of rupture than those from the larger trees, which was significant if the innermost specimens only were compared.

The modulus of rupture was higher in timber laid down more slowly, whether that was owing to dense planting or to the decline in girth increment with age. The strongest specimen had a modulus of rupture nearly twice that of the weakest, but the highest tree mean value was only about one third greater than the lowest; both the trees with the highest and lowest tree means were among those grown at the highest density, where the variance was greatest.

The moments on the trunk of (i) the parts of the trees above ground and (ii) the foliage were calculated, and compared with the product of the mean modulus of rupture and the cube of the trunk radius for each density treatment.

The ratios (of the moments to the calculated maximum loads which the trunk could stand) were higher for the trees grown at the highest density than for the larger trees grown at the lower densities. Therefore if the trees were equally exposed to wind those grown at the lower densities could withstand a greater wind force. However, the exposure of individual trees within stands of different densities may not be equal as the mutual protection may be greater in the denser stands. Thus an estimate of the resistance of whole stands at different densities to wind damage cannot be drawn from this study alone, although there are indications that if the stand was opened in places (e.g. due to excessive thinning or disease losses) the individual trees in the denser stands might be more susceptible to trunk snap.

Further experiments are in progress in which the timber strength of a range of clones is determined.

b. *Postponement of tapping.* In the early RRIM 500 series clone trials, where owing to the war, trees were generally not opened until a girth of 25–26 inches had been attained, there was little wind damage to RRIM 501. In post-war plantings, however, where trees were opened at 20 in. or less, considerable—sometimes catastrophic—wind damage has occurred. Although differences in growth rate, manurial treatment and general upkeep may play a part, the factor most likely to be responsible for the change in wind susceptibility is girth size. An experiment has therefore been set up on a co-operating estate to test the effects of four different sizes at time of opening (22, 24, 26 and 28 in.) on wind damage susceptibility. It is also intended to study the effect of size at opening on yield, on both an area and a tree basis. The first plots (22 in. minimum girth) came into tapping on 1 December 1960.

c. *Pruning and pollarding.* Investigations are in progress to study the effectiveness of various types of pruning in avoiding wind damage, and the effects of such pruning on subsequent growth and yield of the trees.

In two experiments on estates, considerable damage to the trunk bark was experienced after pruning severely, and also after complete pollarding at 12 ft. In both cases, the trees were completely defoliated. The nature and position of the damage on the tree suggested that unaccustomed exposure to the late morning and early afternoon sunshine might be the cause of the damage. Work was therefore started in April 1960 on the Experiment Station to compare pollarding at 12 ft and pruning at 25–30 ft with an unpruned control. Within each of these main plots,

the trees were ranked in order of girths and sub-treatments allocated at random within groups of four:

Tapping, trunk covered with paper.

Tapping, not covered.

Not tapped, trunk covered with paper.

Not tapped, not covered.

Considerable bark damage was observed on the tree which were not covered; some damage also appeared at the base of the covered trunks but only below the level of the paper which finished roughly 6 in. above ground level. Girthing and regeneration were better in the pruned than in the pollarded plots. *Table 13* shows the girth increments for the first six months.

TABLE 13. EFFECT OF TAPPING, PRUNING AND POLLARDING ON GIRTH INCREMENT IN CM FOR A PERIOD OF 6 MONTHS

Tapping treatment	Unpruned control	Pruned	Pollarded
Tapped	2.1	0.4	0.4
Not tapped	4.1	0.8	0.5

Yield in the pollarded and the pruned trees fell almost to a third of the control, but at the end of the year the yield of pruned trees was increasing.

The area of RRIM 501 used for this experiment had been in tapping for roughly nine months when the pruning treatments were applied. The planting system is 60 ft $\times$ 4 ft. Another part of the same field (Field 54) was used for a further experiment. In this case, pruning was compared with partial pruning (removal of half the main branches) and a control. Sub-treatments consisted of tapping treatments (tapped and untapped trees) and covering treatments (paper covering, white-washing and no covering). Pruning was carried out at the beginning of October and, owing to cloudy weather, very little 'sun-scorch' had been detected in any treatment at the end of the year.

d. *Corrective pruning of young buddings.* Treatments were applied to young trees of RRIM 613 to induce a canopy at a suitable height. Treatments included crown budding, pollarding, ringing and bud-notching to induce the growth of selected buds. Subsequent selection of shoots induced by these treatments followed.

At the end of the year some untreated control trees had formed a suitable crown naturally, but the majority had grown extremely tall before branching. In general, branches tended to arise in a well-distributed pattern and over a greater length of stem in trees which had been ringed and notched, a habit clearly preferable to the crowded bunch of branches which developed all at the same height after pollarding.

Improving Germination and Prolonging the Viability of Hevea Seeds

A small trial was made using two inch Sorbex Peat pots for germinating rubber seeds. These compressed peat block cubes have a depression large enough to hold a single seed and were found to be an excellent and convenient medium for

germinating valuable seed. All of the 1960 hand-pollinated seeds were sown in them.

After soaking in nutrient solution for 24 hours the blocks are placed on a shaded and irrigated bench before the seeds are sown. When the seeds have germinated the blocks are planted intact and with no root disturbance into baskets under shade, before they are finally planted in the nursery.

In a storage test with seed from the February harvest (having a very poor initial viability of 34%), seed kept in small polythene bags at room temperature did not germinate after one month's storage; at 40°F germination was 10% after eight weeks.

A more detailed experiment, commenced in September, consisted of storing seed in replicated lots of 50 in different containers at room temperature and at 40°F. Initial viability was 69%. Seed kept for 12 weeks in polythene bags at 40°F gave 60% germination. At room temperature it had fallen to 17%. Viability of the seed stored in hessian bags at both temperatures had fallen below 10% after 6 weeks. This experiment was not completed by the end of the year.

Investigations on *Hevea* seed storage will be extended; the influence of gas environment will also be studied.

TAPPING EXPERIMENTS

Comparison of Different Tapping Systems on Clones and Seedlings

a. *Prang Besar Further Proof seedlings.* The fourth year of tapping was completed in April 1960 and the experiment continues. The following observations are of interest.

- (i) The rate of girdling of trees tapped alternate daily or third daily on a half-spiral cut continues to be similar. Total girdling since opening for tapping in April 1956 is 7.5 in. for alternate daily and 7.8 in. for third daily tapped trees. The mean girth increment during the fourth year of tapping is 1.5 and 1.6 in. respectively.
- (ii) There is a large difference in yield per acre between these two tapping systems. The yield during the fourth year of tapping is 1740 lb per acre for trees tapped S/2.d/2.100% and 1456 lb per acre for trees tapped S/2.d/3.67%.
- (iii) The brown bast incidence is 4.6% on alternate daily and 1.7% on third daily tapping. The trees tapped alternate daily now enter their third year of tapping on the second panel which is expected to be critical with regard to brown bast.
- (iv) The daily periodic systems yielded as follows during the fourth year:

S/2.d/1.15d/30.100%	:	1527 lb per acre
S/2.d/1.1m/2.100%	:	1483 lb per acre

These yields are clearly less than that obtained on S/2.d/2.100% tapping.

- (v) The periodic change-over system S/2.d/2.2×12m.100% yielded 1720

24

 lb/acre, similar to the yield from S/2.d/2.100% and the brown bast incidence is 4.4%. The experiment continues.

b. *High or ladder tapping.* Experiments continue with the main object of studying the response of individual clones and also of clonal seedlings to tapping a high panel after the bark of first renewal of the low panels has been tapped away.

Four more RRIM 500 series clone trials have been changed to high panels one of which is tapped on two cuts at three day intervals for twelve months out of sixteen (2C/2.d/3.12m/16.100%). Results from two of these experiments show very high yields for clones RRIM 501 and 513, which, however, decreased to normal in the second year of tapping.

Observations at the R.R.I. Experiment Station show that clone RRIM 519 is the highest yielder on ladder tapping.

c. *Intensive tapping.* The results of intensive tapping experiments have been given in detail in a paper 'Intensive Tapping of Mature Rubber', read during the Natural Rubber Research Conference of September 1960. These show that alternate daily tapping of two half-circumference cuts (2C/2.d/2.200%) is too severe for high yielding budded planting material. Third daily tapping of two cuts shows promise as a long term tapping procedure.

Five more experiments have been laid out during the year on co-operating estates in which the following tapping systems are compared:

S/2.d/2.100% in renewed bark plus twice yearly stimulant application

2C/2.d/3.133%

2C/2.d/3.12m/16.100%

2C/2.d/3.12m/16.100% plus one stimulant application three months after the resting period.

These experiments are carried out in monoclonal blocks of Pil B84, PB 86, Tjir 1 and also on Tjir 1 clonal seedlings, all planted before 1941. No results were available at the end of the year.

Records are received from estates where these systems are employed commercially. Detailed records are also received from two large scale experiments in which intensive tapping systems are compared with single-cut systems. One of these experiments is carried out on young PB 86 buddings from the time of opening for tapping and is confounded with manuring treatments.

Relationship Between Tapping Intensity, the Use of Yield Stimulants and Fertiliser Treatment

The third year of tapping has been completed in the tapping experiment carried out on clone PB 86 in which three tapping systems confounded with two manuring treatments are being compared. S/2.d/3.67% tapping has to date resulted in a 25% loss in crop per acre when compared with S/2.d/2.100%. Yearly applications of 2 lb R.R.I. mixture C₂ have not yet affected girthing or yield. The response of trees tapped S/2.d/2.100%, to stimulant application has been disappointing throughout the duration of the experiment. Brown bast incidence is negligible. This experiment which is not likely to yield much interesting information, may have to be discontinued in view of more urgent work on other subjects connected with tapping investigations.

The tapping experiment carried out under supervision of the research unit of a leading rubber company, in which three tapping systems are compared at four levels of manuring, continues to show a very considerable higher yield per tree per tapping and also per acre per year for trees tapped 2S/2.d/3.133% (one cut opened at 60 in. and one at 30 in. from the union). A significant retarding effect on girdling has however been induced by double cut tapping. None of the four fertiliser treatments has yet produced an effect on girdling or yield.

The stimulation experiment carried out on the site of a discontinued manuring experiment was stopped during the year. Results are being analysed. No outstanding differences in response to stimulation have been observed between manuring treatments.

Study of Dry Trees

The work to be done on this project has been discussed between research officers of all Divisions and the line of approach has been agreed.

Failure to attract suitable staff has delayed the execution of this work. There is only one experiment in progress in which regular inspection of tapping cuts is made in three tapping tasks in a field planted with clone RRIM 501. One task is tapped alternate daily and the two others third daily. The trees in half of the alternate daily tapped task are treated with a bactericide. No differences in spread of dry trees have been observed up to the end of the year under review, three months after the commencement of treatments.

Leaf and latex samples have been collected from normal and affected trees for analysis of major and trace elements.

Optimum Size of Tapping Task

This is a new project, not included in the research programme. An experiment has been started in which the effect of the size of a tapping task on yield per tapper, yield per acre and standard of tapping is studied. Task sizes vary from 300 to 600 trees. The experiment will be completed in 1961.

PHYSIOLOGY AND MORPHOLOGY

Long Term Experiments on Yield Stimulation

Two long term experiments, one on clonal seedlings, started in 1952, and one on buddings of nine clones, started in 1954, continue to show satisfactory response to half yearly application of stimulant. The trees are tapped S/2.d/2.100%. A comparison made between commercially available stimulant formulations has been reported in detail in *Planters' Bulletin* 51 (November 1960).

The Effect of Growth Promoting and Other Substances on Latex Yields.

The results were summarised of five large-scale field trials in which a variety of synthetic plant growth regulators synthesised at the Agricultural Research Council Unit of Experimental Agronomy, University of Oxford, were tested for their effects on latex yields. These results were presented briefly by Professor G. E. Blackman, F.R.S. in his address 'The Stimulation of Latex Flow by Plant Growth Regulators' at the Natural Rubber Research Conference.

From a practical view point, these experiments have confirmed the soundness of our present recommendations for the use of 2,4,5-T and 2,4-D. In general, 2,4,5-T appeared to be somewhat the more active of the two, although this was not observed in all the experiments. There was evidence that another compound, 2,4-dichloro, 5-fluorophenoxyacetic acid, may be slightly more active than 2,4,5-T; its activity is also apparently less dependent on concentration. The cost of manufacture of 2,4-dichloro, 5-fluorophenoxyacetic acid would undoubtedly be greater than that of 2,4,5-T and it is at the moment doubtful whether its use could be justified on economic grounds. It is hoped that further investigations will enable a decision to be reached on this point.

Also of interest was the observation that there is usually a close correlation between the effectiveness of a compound as a yield stimulant and its activity in inducing a renewed bark of increased thickness when applied above the tapping cut. It has been suggested that, in future, preliminary screening tests might be based on measurements of the thickness of the treated bark rather than on the laborious recording of latex yields at each tapping. The correlation between the two effects was not complete, however, even in the present experiments, and it is known that certain compounds, such as antibiotics and copper salts, which are not normally regarded as plant growth regulators and which may therefore be expected not to influence bark renewal, can stimulate latex yields. The induction of excessive cell proliferation may also be regarded as a disadvantage if it leads, as it frequently does in the case of 2,4,5-T, to uneven renewal and cracking of the treated bark. It has therefore been decided to continue to record effects on both yield and bark renewal in future trials.

Five additional compounds supplied from Oxford were tested during the year, but results are not yet available. A number of other compounds and mixtures were screened on a small scale. A few showed some promise in respect of either reduction in damage to renewing bark or increased yield response and these are undergoing further test.

In co-operation with Chemical Division, a further experiment was laid out to test various combinations of antibiotics and 2,4,5-T. Insufficient results are at present available for conclusions to be drawn. Small-scale trials were also carried out to investigate suitable carriers for antibiotic mixtures.

The Practical Applications of Yield Stimulants.

An experiment was carried out in Field 25(v), R.R.I. Experiment Station, to test the effects on yield and bark renewal of monthly applications above the tapping cut of 2,4-D acid and butyl ester in various carriers. Incomplete results indicate relatively small differences in yield level between the formulations but a much more striking range of effects were noted on bark renewal. Greatly increased bark thickness, uneven renewal, and cracking of the treated bark were noted in formulations containing petrolatum grease and lanoline, whereas palm oil and palm oil/coconut oil mixtures gave a relatively smooth renewal. There was no consistent difference between the acid and ester formulations. Further observations are in progress.

Evidence has also been forthcoming from other experiments that the carrier employed may play an important part in determining the extent of bark damage

following panel applications of yield stimulant mixtures. In view of the convenience and low cost of panel applications, further experiments are being undertaken with the object of producing an improved formulation for commercial use.

The optimum depth of bark scraping before applications of yield stimulants below the tapping cut on virgin bark has not hitherto been investigated critically by the Institute. An experiment was therefore laid out in Field 3 at the R.R.I. Experiment Station, on mixed clones budded in 1930 and tapped V/2.d/2.100% on high panels in virgin bark. Three depths of scraping were compared:—

- A. very light scraping of the outer bark to reveal a greenish layer.
- B. scraping through the greenish layer until a smooth whitish layer (the sclerenchyma ring) is reached.
- C. scraping through the whitish layer into a coarse granular tissue with the appearance of minute beads of latex. Excessively deep scraping involving latex bleeding was avoided.

The yield stimulants employed were 'Stimulex' and the R.R.I.M. formulation of 2,4,5-T. Results for the first four months after treatment show that method C gives the highest peak yield, but there are indications that the fall-off in yield in subsequent months may be slower in the case of the lighter scraping methods.

Attention has also been paid to the use of penetrating formulations which may be applied below the tapping cut without scraping. Further trials with the proprietary yield stimulant 'Ready-Rub' confirmed that satisfactory results may be obtained from its use on virgin bark during ladder tapping. Rather less satisfactory yield increases were encountered in several experiments on renewed bark at low level. A tendency was noted for the stimulant to spread down the bark, causing swelling and cracking below the treated strip. It is therefore considered that not more than two inches of bark below the cut should be treated with 'Ready-Rub' on trees tapped alternate daily. Other penetrating mixtures are also under test.

The Physiology of Tapping and Latex Flow.

Two small-scale experiments were carried out in which a 2,4,5-T mixture was applied to the bark at different positions on the tree. In both cases, the highest yield increases were obtained by applications near ground level on the same side of the trunk as the tapping panel. This is thought to indicate that the translocation of the stimulant to the latex drainage area below the tapping cut may be an important factor in determining the extent of the yield response obtained.

Other experiments have confirmed and extended the observation that the latex drainage area is increased following yield stimulation. Here again, there is a suggestion that the extension of the drainage area is influenced by the position of the application.

The work carried out in the laboratories of the U.S. Rubber Company on the translocation of C¹⁴-labelled 2,4-D and 2,4,5-T in young *Hevea* trees, reported at the Natural Rubber Research Conference, is of great interest in this connection. It is hoped to extend these observations on trees in regular tapping and also to investigate possible practical applications.

During the previous year, a rise in the growth substance content had been noted in extracts made from the latex of trees of clone Pil D 65 stimulated with the

n-butyl ester of 2,4,5-T. When the extracts were fractionated with sodium bicarbonate solution, there was little difference between the activity of chromatograms of the bicarbonate-soluble ('acidic') extracts from the treated and control trees, but a large increase appeared in the 'neutral' fraction from the stimulated trees. In further experiments, on trees of clone Tjir 1, 2,4-D acid and the n-butyl ester have been employed. A rise in activity in *both* the 'acidic' and 'neutral' extracts has been observed, regardless of whether the 2,4-D was applied as the acid or the ester. These results suggest the hydrolysis of the ester to liberate the acid and the conversion of the free acid to a neutral, but still active, form within the tree. This is of considerable importance in the planning of work involving the use of C¹⁴-labelled stimulants.

A close study has been made of the effect of yield stimulants on the rate of flow of latex after tapping. It is clear that the yield increases obtained result very largely from an extension of the period of rapid flow which follows tapping. The actual rate of flow measured during the first five or ten minutes after tapping may be increased, unchanged, or even decreased following the application of 2,4,5-T, but the period of flow is always extended.

Parallel studies on the fluctuation in total solids content of the emergent latex during flow have furnished an explanation of the lower dry rubber content normally observed following yield stimulation. In unstimulated trees, the observations of earlier workers have been confirmed in that the concentration of the latex is seen to fall during flow; sharply at first, but later levelling out and usually rising slightly as flow ceases. At the first tapping following treatment with 2,4,5-T, latex flow continues longer and the concentration thus falls to a lower level in the later stages. The tree is apparently unable to restore the exceptionally heavy losses of latex completely before the next tapping, when the total solids content of the first few samples are lower than normal. The period of flow is still more prolonged and further dilution leads to a yet lower final total solids content. This process continues for several tapings before a new equilibrium is reached.

During discussions at the Natural Rubber Research Conference it was generally agreed that it would be most important to attempt to elucidate as fully as possible the mode of action of yield stimulant compounds and also to undertake a fundamental study of the physiological factors influencing and controlling latex flow. Accordingly, a new programme of work, which will involve extensive co-operation with a number of officers of Chemical Division, was drawn up and a start was made with experimental work during December.

Natural Auxins in Latex

The work on the occurrence of natural growth substances in *Hevea* latex was summarised in two papers; one presented to the Natural Rubber Research Conference and one published in the *Journal of the Rubber Research Institute of Malaya*. Little further progress on this subject has been possible during the current year due to the heavy commitments of the plant physiologist with work on tapping physiology and yield stimulation. It is hoped that, with the appointment of an additional Research Officer, it will be possible to institute a comprehensive survey into the influence of natural growth factors in such processes as latex flow, the rooting of cuttings and abscission of fruits.

GROWTH STUDIES

Growth of Various Planting Materials

The growth of clones RRIM 501 and 513 is compared in two adjacent five-acre blocks. Regular samplings are made for dry weight determinations and height and girth measurements are taken at regular intervals. This experiment has been reported in detail in the paper 'Some Aspects of the Growth of *Hevea brasiliensis*' read at the Natural Rubber Research Conference. In a second experiment a comparison is made between growth of budded stumps and rooted cuttings of clone PB 86. This experiment was planted in November 1960 and no results were available at the end of the year.

A pot culture experiment comparing illegitimate seedlings of clones PB 86 and AVROS 50 showed that the PB 86 seedlings remained superior in height and total dry weight. No differences were observed in the rates of relative growth and net assimilation. In another pot culture experiment a comparison was made between illegitimate seedlings of clone PB 86 and rooted cuttings of the same clone. Complete data are not yet available. Seedlings grew a little taller and produced whorls more rapidly (seedlings grew 7 whorls in the same time that cuttings grew 5). There was little difference in total dry weight, but there was greater stem weight in seedlings and greater leaf weight in cuttings.

The Effect of Tapping on Growth

This is studied on clones PR 107 and RRIM 520. The depressing effect of tapping on girth increment remains unexpectedly small. It has been decided to lay out a further experiment in a more suitable area to continue the study of this interesting problem.

Effect of Size of Stock at the Time of Budding on Growth of the Scion

The first investigation, the results of which have been published, forms part of the experiment in which the growth of clones RRIM 501 and 513 is compared. A second experiment was set up on trees of clone RRIM 519. The girth variation of the stock seedlings was from 2 to 6 inches, measured at 12 inches from the ground. No results were available at the end of the year.

Partition of Assimilates

Carbon for the formation of rubber hydrocarbon is derived from the pool of assimilates available for growth of new tissues. It is possible that differences in the efficiency of utilisation of this carbon for rubber production exist between different planting materials. Carbon assimilation can be estimated by growth analysis methods. Rubber hydrocarbon can be estimated by a method of analysis developed in the Soils Division of the R.R.I.M. Plants grown in pot culture would be a suitable material for investigation. The technique of rubber hydrocarbon estimation using stems and petioles from the seedling/cutting pot culture growth trial are being perfected.

Distribution of Weight in Trees as a Factor in Susceptibility to Trunk Snap.

A considerable amount of data is in the process of being accumulated on the distribution of fresh weight between trunk, branches and leaves in wind susceptible and wind resistant trees. The weight of canopy is determined for each successive 10-foot interval of height to the top of the tree. Tests of trunk wood strength are

made for all the trees so analysed. Scale drawings have been made of a number of trees broken by wind. The object is to determine whether susceptibility to trunk snap can be attributed in part to a relatively top-heavy disposition of canopy weight leading to a turning moment on the trunk which exceeds the breaking strength of the timber.

ECOLOGY

Identification and Classification of Plants Found Growing in Association with Hevea

Fifty-three plant specimens were received from estates and identified; advisory letters concerning these plants were despatched. In addition many specimens brought in by hand were identified for other divisions, advisory officers and representatives of commercial concerns.

Specimens of about one hundred plant species were added to the herbarium collection. At present the herbarium contains nearly 5000 sheets representing 1602 species in 697 genera under 121 families.

Living collections of cover plants were maintained in the 'cover plant museum' at the R.R.I. Experiment Station and Headquarters.

Effect of Cover Plants on the Performance of Hevea

The two oldest post-war trials are in Fields 23 and 24 of the R.R.I. Experiment Station. The main experiment in Field 23 has shown effects in girth attained and girth increments. The growth of the rubber trees has been best in the 'creeping legumes' cover plant treatment, closely followed by that in the plots of the grass *Panicum nodosum*. The next best were the leguminous shrub *Flemingia congesta* and the grass *Axonopus compressus*. The remaining treatments allowed growth less than the trial mean, but the two Compositae, *Mikania scandens* and *Eupatorium odoratum*, depressed growth distinctly more than the others which were the large shrub *Ficus alba*, the small shrub *Melastoma malabathricum* and the heavy grass *Brachiaria mutica*. There were indications that as the shade cast by the *Hevea* trees increased, the grasses *Panicum nodosum* and *Axonopus compressus* withered less during the dry season and were probably becoming more competitive. The trends in treatment effects appear therefore to have entered into a state of flux and premature judgements on long term effects should not be entertained at this stage.

In Field 24 the steep slope has introduced an erosion effect which so far appears to have levelled the cover plant effects. In Field 17 the majority of cover plant treatments have been successfully established and the abandonment of some has not affected the overall design. The trial was budded during the year. The most interesting effects to date were on root disease incidence. This was reduced in the blocks which were mechanically cleared in contrast to those where the old trees were felled and their stumps poisoned. In the latter, woody shrub covers showed an increase in root disease incidence.

Pilot experiments on: (i) mowing of grass to reduce its competitive effect on the trees and (ii) heavy phosphate applications to retain legumes longer, have not yet shown significant effects. An area has been prepared in a replanting for comparison of five different methods of management of both leguminous and non-leguminous covers.

Vegetation sampling was carried out in cover plant trials by a technique devised for use in a wide range of vegetation. The contributions made by different components of the vegetation were judged by their cover estimates, because these allowed better discrimination than did frequency estimates.

The natural cover regeneration plots in trials on four sites with different histories were compared. The species assemblage was richest in a new planting and poorest in a replanting from rubber previously abandoned to *Gleichenia* thicket. The coverage was worst on a hill-site. *Trema orientalis* was associated with recent burning, whereas *Ficus alba* was more common in unburnt areas. The majority of the main natural constituents of the vegetation have seeds dispersed by animals (especially bats and birds).

The details of the technique and the results are reported in the paper 'Vegetation Sampling in Cover Plant Trials', contributed to the Natural Rubber Research Conference. Further use of the data is possible to determine degrees of association between species in communities. A series of samplings will allow the pattern of succession to be studied as the trees mature.

Studies of soil pits were carried out in the main cover plant experiments at the R.R.I. Experiment Station, to determine rooting depth and density of the different covers and *Hevea*. Distinct differences in green matter, litter, humification, rooting depth, etc. were evident between sites and cover plants.

A small scale experiment was started at the end of the year to observe the rate of root spread and the root system morphology of cover plants.

Production and Storage of Leguminous Seeds

No new work has been initiated on the treatment of leguminous seeds during the year.

The heavy losses suffered by the most commonly used legumes through pest attack have made their continued employment increasingly costly and difficult. Therefore attention has been turned to the possibilities of extending the number of leguminous cover plants in use. To this end, ten uniform 'Legume Adaptability Trials' have been set up on a range of soils in which forty different species are tried in small plots. The species include those which are currently used, others which have been used in the past and also potential new covers, both imported plants and native selections.

CONTROL OF FIELD EXPERIMENTS

Optimum Plot Size

Because of heterogeneity in most experimental areas, there is a need for small plots and more replications. The size of the plot however, is limited by the need for boundary trees. In the new clone trials the plot size has been reduced to 0.3 acres and the number of replications has been increased to 5 or 6.

With the object of studying the problem of optimum plot size (and shape) in more detail, one uniformity trial has been carried out on clone RRIM 501 and others have been proposed.

The study of variation within clone RRIM 501 confirms that, apart from yield itself, girth would appear to be the most suitable, single, easily determined criterion for the selection of trees within a clone. However not more than approximately half the variation in yield could be attributed to girth and bark thickness, or d.r.c. which indicates the probability that other important factors exist which influence the yield. Further investigations will be made.

ADVISORY

Research Officers lectured to senior conductors, Senior and Assistant Rubber Instructors attending courses, and to students of the College of Agriculture, Serdang. Four lectures were given to Incorporated Society of Planters' branches in Perak, Negri Sembilan and Malacca.

Nearly all routine advisory work has been carried out by the Estates Advisory Service. Some advisory duties were, however, included in the 223 visits made by Research Officers to estates during 1960. A considerable amount of advice was given by letter.

The services of our clone specialists remain in high demand. They visited 166 estates and smallholdings where they checked budwood nurseries and inspected clonal seed collection areas. A few estates in Singapore were also visited. At the end of the year the total acreage in Malaya approved for the collection of clonal seed was 40,992 acres on 183 estates.

Distribution of Cover Plant Seeds

In addition to the seed of forty species distributed to estates for the legume adaptability trials and that given to overseas institutes and visitors in exchange for new species, nucleus quantities of *Clitoria rubiginosa* were sent out to estates for multiplication and trial. A total of 21 pounds of *Clitoria rubiginosa* seed was despatched to 69 recipients. Seed or cuttings of eleven other species were sent to seven other estates or local experimental stations.

Testing of Cover Plant Seeds

Testing of seed samples submitted by commercial concerns continued on a routine basis. Seeds of *Calopogonium mucunoides*, *Centrosema pubescens*, *Flemingia congesta* and *Pueraria phaseoloides* were submitted.

Despatch and Receipt of Planting Material During 1960

Budwood was dispatched to the following countries during the year: Great Britain, Indonesia, Thailand, North Borneo, Brunei, Nigeria and Burma. Budwood was also received from Ceylon and some seeds were sent to Great Britain.

C. W. BROOKSON
Head of Botanical Division

Pathological Division

On the 1st June the Field Research Officer, Mr F. W. Hutchison, transferred to the Estates' Advisory Service as Head-Designate. Mr Hutchison joined the Division on 4 May 1948 as an advisory officer, and the following year became Field Research Officer, in which capacity he has rendered most valuable services to the Division, particularly in developing an eradicator campaign against *Dothidella ulei*, and in supervising large-scale field experiments in relation to root disease control. The vacancy created by Mr Hutchison's transfer remained unfilled at the end of the year.

RESEARCH

ROOT DISEASES

Inoculation Experiments

A fungicidal paint and a fungicidal grease applied to the collars of inoculated young trees have shown promise of giving a useful degree of protection against *Fomes lignosus*. The naturally infected roots used as inocula were placed against a lateral root about two feet away from the collar. When examined a year later, it was found that superficial growth over the treated parts, and penetration of the wood beneath, had both been largely prevented.

The marcots planted in 1959 in part of Field 17, for the experiment on the tolerance of clonal root stocks to root disease, have now all been replaced by rooted clonal cuttings. Further material is being planted as it becomes available, in part of Field 42 West. Thirty-four clones have been established, but more material of almost all of them is needed before the experiment can start.

There is, as yet, no overall effect on yield in the experiment in Field 42 North where 20-year-old trees were inoculated in May 1958 with the three major root parasites. It was thought that the very large natural inocula used would have ensured an early onset of disease symptoms, especially as the trees in all plots are unthrifty. This is reflected in the small size of their leaves, and a recurring die-back. At the end of the year there had been only one mortality; surprisingly, it was a tree infected with the slow growing pathogen *Ganoderma pseudoferreum*. Upon examination it proved to have a heart-rot which may have contributed to its early death. An unidentified white fungus has been isolated from the rot and an attempt will be made to establish its pathogenicity. The condition, if widespread, might afford an explanation for the susceptibility of certain clones to wind damage.

Fundamental Studies

Single basidiospore isolates of *F. lignosus* from *Hevea brasiliensis* have been examined to see if their growth rates fall into the groups previously noted for isolates obtained from different hosts (*Annual Report 1959*, page 62). Too few have yet been examined for an assertion to be made, but it seems likely that there will be continuous variation of growth rate, ranging from as fast as the group from non-*Hevea* isolates to as slow as the group from spores and sporophores.

All previous experience has shown isolates of the fungus, whether obtained from rots, fructifications or spores, to be remarkably stable in culture. It is of interest, therefore, to record that the growth rates of many single spore isolates obtained from one fructification originating at the Experiment Station are unstable, exhibiting cyclic saltation.

A detailed study of the nomenclature of *F. lignosus* and related fungi, carried out in the United Kingdom, indicates that the fungus often confused with *F. lignosus*, and hitherto referred to in Malaya as *Polyporus rugulosus*, should be called *P. zonalis*. This species belongs to a world-wide species complex which is characterised by the production of pocket rot. The status of the name *F. lignosus* for the white root disease fungus will remain uncertain until further comparisons are made with the type specimens.

Studies have been continued on factors affecting rhizomorph initiation and growth. It has been confirmed that different isolates differ in their tendency to form rhizomorphs.

Spore Dissemination

The difficulty of following environmental effects on sporulation in the laboratory, because of the limited life of detached sporophores, has been overcome by inducing sporophore production from cultures, using a modification of the method described by Tamblyn and Da Costa. Several brackets up to 2 cm in diameter formed and spored heavily. A clock-driven moving-slide trap has been constructed for use in the laboratory. The development of sporophores in the field has been studied and their spore production followed. The possibility of insects playing a role in the dissemination of spores is being borne in mind.

Volumetric trapping of *G. pseudoferreum* spores was continued for seventeen days with three traps operated simultaneously at 2, 3.5 or 5 metres from the sporophore. More spores were caught at 5 metres than closer in. The effect of lowering a polythene sheet over the sporophores, to keep them from drying out during the hotter part of the day, was seen in reduced spore catches; even so, except for an hour before noon, there were always some spores in the air from sources outside the experimental area.

The remaining 31 of 43 stumps felled and inoculated with spores of the three major root diseases have been dug out one year after inoculation, and isolates made from the wood. There was no infection by any of the three inoculated fungi. It may be that the stumps need to be weathered before infection can occur. *Trametes corrugata* and *Polystictus vittatus* were the fungi most commonly isolated. Until a successful method of spore inoculation is found, evidence for spores initiating infection and of stump treatments preventing it remains largely circumstantial. A standard method of spore inoculation would also simplify the comparison of different stump surface treatments.

Three experiments have been laid down on the Experiment Station to investigate further the role of spores in stump colonisation. In Field 23A, stumps of trees felled at the beginning of July received four treatments in equal numbers, at random: poisoning and sealing the cut; neither poisoning nor sealing; poisoning only; sealing only. To ensure a spore load in the air where this experiment is

situated, twelve large stumps infected with *F. lignosus* have been brought in and 'planted' under polythene shelters which are raised at night to release the spores. In Field 14C and D West, four treatments were randomised on poisoned stumps in the one-acre plots of the old density-of-planting experiment. The treatments were: painting creosote on the cut surface as well as on the outside of the stump; painting the cut surface only; painting the outside only; no treatment. In Field 21 a comparison is being made between pentachlorophenol and creosote as stump protectants against spore colonisation. There are three concentrations of pentachlorophenol, dissolved in diesel fuel oil.

Treatment effects will be assessed over the next few years as the disease on the young plants reveals those stumps which have become sources of infection.

Field Experiments

In experiment CI-56, four rounds of inspection and treatment (rounds 5-8) were made during the year. The incidence of disease has fallen considerably. It is almost entirely due to *F. lignosus*, with a few cases of *Fomes noxius* but no *G. pseudoferreum*. The cumulative incidence figures do not show large difference between treatments; however, the incidence of disease was higher after stump poisoning with 2,4,5-T or sodium arsenite than after poisoning the standing trees, later felling them after one or two months. The cumulative incidence figures in those plots where the stumps received a treatment of the cut surface is now only 20% less than in plots where no surface treatment was given, although only half as many stumps were found as sources of infection.

In experiment SR-57, four rounds of inspection and treatment (rounds 5-8) have been carried out during the year. The experiment was laid down in a 1957 replanting, primarily to test different degrees of eradication of root disease from the old stand at the time of clearing. Altogether, 80 trees were found attacked over the 30 acres of the experimental area. The incidence and loss figures in the second year of recording have been such as to reduce apparent differences between treatments found in earlier rounds, but it is still too early to assess treatment effects.

Four rounds of inspection and treatment (rounds 3-7) have been carried out in experiment J-57. Despite a very high incidence of *G. pseudoferreum* on the old stand, the incidence of disease in the replanting remains extremely low. In the 40 acres of the experimental area, only 15 cases of root disease were found during the year, comprising 9 of *F. lignosus*, 5 of *G. pseudoferreum* and 1 of *F. noxius*.

Two new experiments on the control of root disease, of similar design, were laid down on two well separated estates, with different soil type and terrain. Experiment B-60 is located on a flat low-lying area, over most of which the soil is a stiff clay liable to become water-logged after heavy rain. A total of 643 4½-year-old Tjir 1 clonal seedlings were treated. Experiment SY-60, located on a steep-sloped hilly area with a lateritic soil, is also planted with Tjir 1 seedlings, six years old, of which 327 were treated. Individual records have been taken for each treated tree. There were ten treatments, some were contrived to show whether parts of the currently advised control procedure are unnecessary, others to show whether the disease could be controlled by applying a fungicide over penetrated parts of the collar and tap-root, without excising infected tissue.

The results of experiment B-60, assessed six months and one year after treatment, have shown that scraping off superficial rhizomorphs and application of a fungicide are unnecessary when penetrated roots have been excised and the source of infection removed or isolated. With regard to the second objective, it was found that 50%–80% of the treated trees recovered following the removal of dead laterals and the source of infection. If any advantage can be gained from applying a fungicide over the surface of the penetrated part of the taproot or collar, without cutting out the dead tissue, it has not been demonstrated with the materials used.

Tree and Stump Poisoning

Experiment S-60 is a small, short term investigation of tree poisoning with 2,4,5-T where the poisoned trees have been felled at weekly intervals after application of the poison. It is being carried out to check on previous results, which were contradictory. The starch content of the roots of sample trees has been estimated, and the first set of roots examined to record the extent of death.

Experiment BP-60 is a new experiment laid down in a jungle clearing on an estate in Johore, in a region where root disease has been particularly severe. The experimental area comprises twenty acres, divided into four blocks, in two of which the jungle trees were poisoned with 2,4,5-T, trees in the other two blocks being left unpoisoned. The poisoning was done in July-August 1959; the area was felled in November, burnt in March 1960 and planted in September-October. A creeping legume cover is being established.

One object of the experiment is to assess the effect of the poison on different trees species, by observing the effect on the canopy. Scored records have been obtained after 3, 6 and 12 weeks, the last observation being made shortly before the trees were felled.

A second objective is to identify the sources of root disease infection of the young stand. To this end 2,700 trees have been identified, falling into more than 300 species. In this work we were fortunate in having the help of the Forest Research Institute, assisted by Mr Chandapilla of the Botanical Division. The trees were marked with embossed metal labels durable enough to withstand the subsequent burn.

A third objective is to see whether poisoning the trees prior to felling and burning them will have an effect on the incidence of root disease in the rubber. Unless there is a pronounced effect, which is what would be of interest to us, the existing layout may fail to show a difference, there being only two replications.

Decay of Rubber Wood

In Field 6 on the Experiment Station, one tree and one stump from each of the eight treatments (*Annual Report 1958*, page 51, and *Annual Report 1959*, page 62) have been dug out three years and three and a half years after poisoning. The decay of the above-ground and below-ground parts of both stumps and trees was far advanced, the wood having been reduced to a soft friable mass. Decay was somewhat more rapid following stump poisoning than poisoning the standing trees. Also, confirming earlier observations, poisoning with 2,4,5-T brought about more rapid decay than does sodium arsenite. There were indications that insecticidal treatment slowed down the process of decay.

A second and larger experiment has been laid down in Field 14E(ii) on the Experiment Station, to check the results of the Field 6 experiment. It includes a comparison of a creeping legume with no cover, as an additional pair of variables.

Monthly observations on the fungal fruitbodies on 2,4,5-T poisoned stumps in Field 19 (*Annual Report 1959*, page 63) were continued. The first fructifications to appear were those of *Schizophyllum commune*, quickly followed by *Lentinus blepharodes* and an unidentified species of *Lentinus*, then by *Polystictus occidentalis*, which became dominant. Other fructifications, in order of development, were *Trametes corrugata*, *Polyporus scopulosus*, *Daldinia concentrica*, *Ganoderma applanatum* and *Ganoderma lucidum*. In addition the following were recorded: *Lenzites palisoti*, *Polyporus zonalis*, *Xylaria* sp., *Kretzschmaria cetrarioides*, *Ustulina zonata* and *Polystictus sanguineus*. *S. commune* had practically disappeared nine months after poisoning. The fructifications of *Lentinus* and *P. occidentalis* declined considerably after one year. The most prominent fungus eighteen months after poisoning was *G. applanatum*.

PANEL DISEASES

Two new materials tested during November did not give satisfactory control of mouldy rot.

BRANCH DISEASES

Records have been maintained of the routine pink disease treatment on the Experiment Station. The incidence remained low until the last quarter, when there was a slight increase. No experiments or detailed observations were made.

LEAF DISEASES

Bird's Eye Spot

In the experiment on the control of bird's eye spot (*Annual Report 1959*, page 65) a further fifteen applications of ferbam and ziram were made at weekly intervals, at the rate of 3 lb of the active ingredient per acre. No further applications were made with phenyl mercury nitrate or mercurised copper oxychloride, the former caused yellowing of the leaves, while the carrier oil used for the latter proved phytotoxic. Results were assessed by weighing a random sample of twenty plants from each plot, and by counting the numbers of buddable plants. Judged by both methods, both ferbam and ziram showed highly significant increases over the untreated controls. Despite the restricted number of applications, phenyl mercury nitrate showed a significant increase in weight of plants over the controls, while a decrease in the number of buddable plants was not significant.

Corynespora Leaf Spot

Corynespora cassiicola (Berk. & Curt.) Wei, common on papaya in Malaya and recently reported from *Hevea* nurseries in India, has been found causing a leaf spot on iron-deficient nursery plants growing on the Experiment Station.

PESTS

Termites

Heptachlor was found to be an effective insecticide for the control of *Coptotermes curvignathus*, and therefore has been included in the list of insecticides recommended against this pest, used at a concentration of 0.05% of the active ingredient.

Cockchafer

Soil samples were collected from around trees treated last year with 0.1% heptachlor, 0.1% aldrin or 0.2% chlordane, for the control of *Holotrichia bidentata* grubs on an estate in Negri Sembilan (*Annual Report 1959*, page 65) where the soil is a sandy loam. Tested for residual toxicity against *H. bidentata* grubs, only the heptachlor- and aldrin-treated soils were found to have retained their toxicity. Heptachlor was superior to aldrin in that the grubs were killed more quickly.

A laboratory test to compare the depth of penetration into the soil of three formulations of aldrin emulsion and one of heptachlor, showed the last to penetrate two inches deeper than the best of the three aldrin formulations. Its insecticidal effect was detected six to eight inches below the surface, using *C. curvignathus* workers as the test insects.

Light traps of three designs, with four types of light source, were tested on two estates near the Negri Sembilan - Malacca border. The traps were operated between January and May, covering the flying season. A peak period of flying occurred in the second half of March. Most beetles were caught during the hour after dusk. They were much more attracted to ultra-violet than to white light. A design incorporating a 15-watt 18-inch black light fluorescent tube was selected for future investigations.

Other Pests

A severe outbreak of caterpillars of *Tiracola plagiata* on young rubber seedlings on the Experiment Station was brought under control by one application of 5 gallons per acre of 0.025% endrin, using knapsack mist-blowers. Two new unidentified species of bark-eating caterpillars have been collected on the Experiment Station.

Rogor 40, a systemic and contact insecticide, was found to be effective at a dilution of 1: 1000 for the control of the mealy bug *Planococcus citri* and the scale insect *Saissetia nigra* infesting young rubber plants.

PESTS AND DISEASES OF COVER CROPS

A bait in pellet form containing 9% metaldehyde, applied at the rate of 20 lb per acre, was found to be satisfactory for the control of slugs in legume covers.

A *Meloidogyne* infesting *Calopogonium mucunoides* on an estate in Pahang is believed to be a new species. If confirmed, this would bring the number of species recorded on the commonly used legume covers to four, one of them comprising two strains. We are indebted to Dr Mary T. Franklin, of Rothamsted Experimental Station, for her assistance in identifying these nematodes.

MISCELLANEOUS INVESTIGATIONS

Protection of Flowers

Dusting has been carried out during the main flowering season in the Smallholders' Seed Garden A on the Experiment Station, to compare sulphur and DDT, alone and combined, with untreated control plots. Two clones (PR 107 and TK 14) produced too little seed for an assessment to be made. Clone BR 2 showed no treatment effects, but the seed production of RRIM 501 and Tjir 1 was increased by the sulphur application. On Tjir 1 there were indications of an additional beneficial effect of the DDT.

ADVISORY

Routine advisory work on pests and diseases was dealt with by the Estates' Advisory Service from 1 July, but a limited amount remains with the Division, including some examination of specimens and replies to queries concerning the principles on which advice is based. Research officers made twenty visits to estates and smallholdings and advice was also given by letters and interviews. A lecture was given at the North Perak branch of the Incorporated Society of Planters.

Two senior Field Assistants have between them visited 62 estates during the year, to instruct pest and disease gangs in the control of root disease.

It is clear from visits and correspondence that a belief in a purely chemical treatment for root disease, which had gained some currency, is giving way to the opinion held earlier—of the importance of disposing of the sources of infection. It is not always easy to assess how much digging is required in a given situation. In a young area where the disease is mostly *F. lignosus* and the stumps are rotting away under a heavy cover, it may be sufficient to eliminate infective material only from the planting rows. In an area where the stumps are more persistent and *G. pseudoferreum* is the dominant disease, it will be necessary to follow infected roots into the inter-rows, removing or isolating the boles.

Several enquiries have concerned replantings heavily attacked by red root disease from the fifth year onwards. Although in each case the advised methods of root disease control had not been followed, it is as yet uncertain whether plantations on inland soils will escape a late *Ganoderma* attack when control measures have been carried out from the beginning. The chief aim of the precautionary round of collar inspection advocated in *Planters' Bulletin* 35 is to detect such an outbreak in its early stages.

Unthrifty growth of seedlings planted for field budding has been encountered in several locations on poorly drained soils, associated with *Gloeosporium* on the leaves. It was found that many small lateral roots of badly affected plants were dead, suggesting the possibility of a minor root rot being involved.

On other subjects the number of enquiries received does not reflect the relative importance of the various diseases and pests in the field. Thus, we were not consulted about bird's eye spot, against which it is known that we have found control measures uneconomic, yet there were many enquiries about *Gloeosporium*

leaf disease, which can be controlled by spraying. A few cases of secondary leaf fall were reported, though the circular which was for many years distributed annually is no longer sent out.

There were enquiries concerning pink disease, and various forms of shoot and branch dieback. Among injuries of non-parasitic origin were three cases of accidental poisoning, seven of sunscorch or heat injury and nineteen of lightning damage.

Among pests there were the usual records of local attacks, mostly by mites, coccids, molluscs and rodents. Cockchafers, however, were the pests that gave rise to most advisory correspondence during the year. Of twenty estates where outbreaks had occurred, five reported re-attack following outbreak in previous years. Considerable interest was aroused by the account in *Planters' Bulletin 51* of light trapping, which holds promise as a practicable method of control, as well as being a useful research tool.

A characteristic spiral damage to the bark of young trees, hitherto suspected as being caused by woodpeckers, has proved to be the work of the common red-bellied squirrel *Callosciurus notatus*. Bandicoot rats (*Bandicota indica*) caused considerable damage to the bark of one-year-old budgrafts on an estate in Kedah. Pelandok (*Tragulus javanicus*) damaged three-month-old seedlings growing on the Experiment Station near the jungle edge, the pendant leaves being eaten. A plague of spring-tails that occurred on an estate in Kedah was troublesome only to the extent that their bodies contaminated the latex.

Dying back of cover crops, often associated with pests or diseases, has given rise to much correspondence. Creeping legume covers have been found generally to suffer attack by a *Rhizoctonia*. Dieback of *Desmodium ovalifolium* has been found associated with pink disease and with a *Fusarium* on the root system. A virus has been suspected as the cause of a disease of *Pueraria phaseoloides* on an estate in Negri Sembilan, where there was interveinal yellowing of the leaves. An unidentified Jassid bug was associated with it.

A. NEWSAM

Head of Pathological Division

Chemical Division

The account of the work carried out by the Division which follows is presented in two main sections: (a) Research and Technical Development, and (b) Advisory and Technical Services. The account given is not exhaustive but covers the more important investigations which have been carried out and reports the activities of services provided by the Division.

The basic objectives at which our investigations under (a) are aimed are reduction in cost of production and improvement in quality. To achieve these ends we are studying not only how to cheapen methods of preparation and means of upgrading current types of rubber, but also the possibilities offered by different and more efficient methods of manufacture, the production of rubbers which compete better with synthetic elastomers in presentation and properties, and the development of new, special purpose rubbers which not only help to maintain the position of natural rubber in the changing field of consumer requirements but also offer the producer a better return for his efforts.

Our investigations usually start with fundamental studies to discover new essential facts, which are then applied to the problems of rubber production, and end with the development of new processes for commercial application. A brief statement of our findings during 1960 follows in three sections: Fundamental Research; Applied Research and Technology and Process Evaluation and Factory Studies.

FUNDAMENTAL RESEARCH

BIOCHEMISTRY

Fractionation of Fresh Latex

The study of techniques for separating and analysing latex components has been continued with interesting developments in our understanding of centrifugation at high speed. The pattern of zones obtained from PB 186 latex when collected and centrifuged under standard, refrigerated conditions has been reproduced with only minor changes after an interval of two years with latex from the same group of trees. The amount or intensity of colour of the orange zones (4 and 7), were greater when a new tapping panel was opened, but the effect disappeared as tapping continued. Observations on latex from mixed seedling trees in the same field showed a pattern similar to that given by PB 186, with some differences in the amount and colour intensity of the various zones. It is now clear that the basic pattern of eleven zones first described in 1958 for PB 186 latex (*Figure 1*) is of general significance and is not peculiar to one clone.

Differentiation between the zones is helped by the fact that some are coloured by vital stains such as neutral red and Janus Green B. It has now been demonstrated that with PB 186 latex zone 7 is not homogeneous, since it contains particles of white and yellow granular material which remain unstained, whereas the matrix in which they are embedded is stained green by Janus Green B whilst chilled, and upon brief incubation at 30°C becomes red, indicating reduction of the dye.

The aim of the present work on centrifugation is to separate out the particles responsible for the various zones with a view to characterising them. Microscopic studies have demonstrated that aggregates of particles connected by filaments occur in fresh latex. Centrifuge studies carried out at different speeds have now shown that most of the sedimentable material is deposited at the low speeds obtaining early in the standard centrifugation process. Changes in the separated fractions appear to occur at higher speeds when the centrifugal forces involved become greater, e.g. at 60,000 g., and may account for striations in the pattern of zones thus obtained. Heavy and light particles, e.g. rubber or Frey Wyssling particles and lutoids respectively, may be torn from the reticulated structure in which they first occur and rearrange themselves according to density during the operation, thus changing the pattern into which they first settled. The possibility of introducing a controlled, disruptive step, similar to the homogenisation procedures commonly used in biochemical preparations before attempting fractionation, has now to be considered.

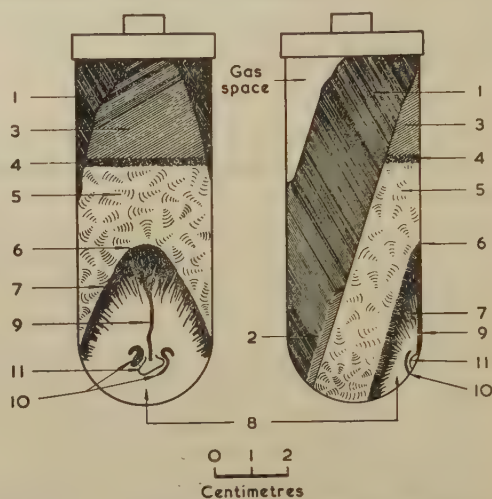


Figure 1. Diagram showing eleven different zones of fresh latex separated by high speed centrifugation.

Latex Proteins

The separation of latex proteins forms part of a programme to study the more important of the non-rubber constituents in latex. The first step is of course separation and isolation of the protein components before characterisation can be undertaken. Three methods are being used, paper and starch gel electrophoresis, and ion exchange chromatography.

Paper electrophoresis is now used for routine work and gives reasonably reproducible results. Difficulties of non-reproducibility have been experienced in the use of starch gel electrophoresis which have now been found to arise partly from the use of an unsuitable starch and partly from the effect of starch concentration in the gel. Although the latter has always been standardised, it was not appreciated that the starch used is markedly hygroscopic under Malayan conditions and contained varying amounts of water. A revised procedure has been adopted using a special grade of starch (Connaught) which is desiccated before weighing; it is at present giving reasonably reproducible results. Further work is needed before the technique used can be regarded as suitable for investigating differences between latices from various clones.

Ion Exchange Chromatography

Further studies using ion exchange chromatography have been made with the fluid obtained by freezing and thawing the bottom fraction resulting from high speed centrifugation of latex (B serum). The eluate obtained on passing B serum

through CM cellulose at pH 5 shows only one component as judged by paper electrophoresis, but two main and several minor constituents on starch gel.

The two main constituents (a) and (b) have now been separated by elution of (b) from a column of DEAE cellulose at pH 6, followed by elution of (a) at pH 4.5. The amount of (a) obtained was small and no further characterisation has been attempted. Protein (b) crystallises in a form identical in appearance with hevein, and gives an ultra-violet absorption spectrum very close to that of the latter material. Elemental analysis gave nitrogen content as 16.79 per cent and sulphur 5.32 per cent, which agree quite well with determinations on an earlier sample prepared by a different method. The nitrogen content is still higher than that of hevein, 15.7 per cent, and identity of the two materials is still in doubt.

It is of interest to record that protein (b) was observed to form cubic crystals, which on rapid recrystallisation from chilled water reformed as needles. This component thus appears dimorphic, which may have a bearing on the identity of the prisms illustrated in *Annual Report 1958*.

An examination of B serum proteins remaining on CM cellulose after elution at pH 5 has also been made. For this purpose a pH gradient-generating device was constructed, which permitted elution of proteins by stages from CM cellulose over a range of pH from 5 to 7.6. The graph plotting amount of protein eluted against pH showed five major peaks. Investigation of the degree of homogeneity or complexity of the components thus separated has yet to be completed.

Non-protein Nitrogenous Constituents of Latex

An examination of the non-protein nitrogenous constituents of latex has just been commenced. These materials are thought to include amine-type components which play an important role in the vulcanisation of latex and dry rubber, and components reacting with peroxides to produce free radicals which in turn lead to crosslinking or degradation of the rubber molecule, depending upon conditions.

Preliminary trials using ion-exchange resin fractionation and paper chromatography for separation of the individual constituents are now being undertaken.

MICROBIOLOGY

Counting and Identification of Bacteria

Improvements have been made in the technique for viable counts of bacteria, both aerobic and anaerobic. It is now apparent that both field and concentrated latex can bear considerable populations of anaerobes, although wide variation in the numbers present have been observed. A considerable amount of work remains to be done before any assessment of the situation regarding commercial supplies of latex can be made.

A number of tests, including haemolysis, gelatin liquefaction, coagulase reaction, and staining methods, have now been set up in the routine bacteriological laboratory and are proving useful supplements to existing methods for identification of bacterial species. It is hoped eventually to be able to relate, in a broad way, the deleterious activity of the more prevalent species with latex behaviour.

The compilation of an atlas of bacteria found in various types of latex has been started; this includes photographic records of colony and cell morphology, as well as metabolic data. The resulting codification of observations should simplify the task of identifying latex micro-organisms.

Samples of latex examined in the laboratory often have to be transported over long distances by rail or road. The time from estate to laboratory is thus variable, ranging from less than an hour to 48 hours or more. Experiments undertaken to test whether icing of latex samples during transport would effectively stabilise the bacterial population have yielded promising results. Under laboratory conditions chilling of samples maintains the level of population unchanged over a period of four to five days. Further trials in co-operation with estate factories have now to be undertaken.

Effect of Bacterial Metabolism on Latex

An important question concerning latex concentrate preparation is the effect on properties produced by contamination with bacteria, and a major part of our research effort in the bacterial field is directed towards obtaining the answer.

Volatile fatty acid (V.F.A.) formation has been found to be due almost entirely to bacterial activity and recent experiments confirm that although there may be a slow intrinsic liberation of V.F.A. from stored, unpreserved, fresh latex free from detectable viable contamination, the amount involved is negligible compared with that liberated in contaminated, unpreserved latex systems.

To assess the formation of V.F.A. by individual bacterial species in fresh latex is a complex proceeding, and experiments so far have been carried out on sheet serum. It has been found that bacteria can be grouped roughly into three classes. The first comprises species which produce rapid increase in V.F.A. including anaerobic *Streptococci* and aerobic *Enterobacteriaceae*, such as *Serratia marcescens*; the rate may be as high as 0.3 V.F.A. No. units in 24 hours. The second group produces V.F.A. more slowly, and shows this activity only well after the logarithmic increase phase; the rate here is at a level of 0.01 or 0.02 units per day. The third group produces very little or no volatile acid over prolonged periods.

An interesting further category may be exemplified by capsulated gram-negative bacteria isolated from trees subject to brown bast. In pure culture, these organisms liberated V.F.A. slowly, but growth was not vigorous. In the presence of V.F.A. forming bacteria, such as *Serratia marcescens*, the capsulated organisms grow well and utilise the volatile acid present, possibly to synthesise mucopolysaccharides. The V.F.A. content then falls.

Total acid content of latex, as measured by the KOH number test, is often found to increase with increase in viable count, in respect not only of volatile, but also of 'fixed' acids. This is not invariably the case, however, and instances have been observed where 'fixed' acids remain low, with marked increase in volatile acids, and where fixed acids increase with volatile acids remaining constant. At present, however, there is evidence which suggests that the fixed acid content always remains low (KOH No. below 0.40) if care is taken to prevent the viable bacterial count rising to a high level at any stage of the preparational procedure, including field latex.

Bacterial Contamination of Trees

A large scale experiment has been undertaken in Field 18B at the R.R.I. Experiment Station, in collaboration with the Botanical Division, to examine further the effect on yield produced by treatment of the tapping panel with bactericides and antibiotics. The trial was commenced at the end of November 1960,

and although differences in the treatments showed up almost immediately after application, insufficient time has elapsed to make an appreciation of the total effects.

Further studies throughout the year on Tjir 1 buddings in R.R.I.E.S. Field 47 have confirmed that in these trees contamination of the latex vessels has remained at a level of one hundred to one thousand viable bacteria per millilitre of latex. On no occasion has sterile latex been obtained despite rigorous techniques of extraction. The trees are, of course in regular tapping.

It is a debatable point whether rubber trees react to contamination of latex vessels with bacteria in the sense of developing immunity to bacterial toxins by producing antibodies. If such a reaction occurs, it could lead to differences in the latex proteins. A brief experiment was carried out comparing latex proteins from Tjir 1 trees newly opened and others in regular tapping, using paper and starch electrophoresis. A definite difference in pattern was observed. Care is needed in interpreting these results as differences in the proteins could arise in a variety of ways.

Experiments with tapping knives, bearing a small tank for holding liquids, have been made with the intention of delivering small amounts of bactericide or other reagents to the cut at the time of tapping. The knives work well for experimental procedures, and have reduced the incidence of bacteria in latex but have not proved very practicable in their present form for routine field use.

Another way of introducing bactericides to the tree has been examined. This consists in applying gaseous substances to a limited area of the bark encased in a polythene jacket. Ethylene oxide was the bactericide first used. The effect was striking since latex continued to flow after tapping for well over 24 hours; the yield was 350 ml as compared with 70 ml normally obtained from the tree. Thereafter, the tree was dry. Less drastic treatments were tried using lower levels of ethylene oxide, but with the same result, a marked outpouring of latex followed by a decline to zero after a few tappings. In all cases marked bleeding of latex from healed wounds and branch forks was observed. At a later stage necrosis of the bark followed.

Treatment with gaseous ammonia was then attempted with marked increase in yield for the first few tappings. As signs of bleeding were observed at this stage, treatment was stopped. At the time of reporting, two or three weeks later, yields are still above normal.

Brown Bast

An interesting observation has been made on trees showing brown bast. In four separate occurrences investigated, the diseased areas of bark were found to be contaminated with large numbers of gram-negative capsulated bacteria. Further observations and experiments are being carried out in co-operation with the Botanical and Pathological Divisions.

COLLOID CHEMISTRY

Microscope Studies on Latex

The systematic examination, using a phase contrast microscope, of the particles comprising the different zones into which fresh latex can be separated by high speed centrifuging has now been completed. In chilled, fresh latex, eight different types of particle have now been described (Natural Rubber Research Conference, Kuala Lumpur, 1960), and the presence of more complex structures established.

The complex internal structure of lutoid particles found in the bottom fraction after high speed centrifuging, has been confirmed and photographed (*Figure 2*). They are spherical bodies bounded by a membrane and contain a fluid in which smaller interior particles can be seen in active Brownian motion.

After the membrane has been disrupted by ultrasonic vibration, the fluid contents are released and appear identical with B serum, which can be obtained from bottom fraction by repeated freezing and thawing. This serum has a higher specific gravity and is slightly more viscous than latex serum (C serum). Techniques are being developed for isolating and examining the interior particles, which at present do not appear to be rubber; examination of the outer membrane is also in hand.

In whole fresh latex which has been chilled at collection, aggregates of lutoids, rubber, Frey-Wyssling and other particles have been observed, apparently held together in a matrix of viscous material which also contains thread-like processes.

During centrifugation of latex, these aggregates appear to be partially disrupted, and thread-like structures with or without attached particles can be seen throughout the centrifuge tube. In latex from certain clones (e.g. PR 107) pear-shaped rubber particles can be clearly seen, attached to stalk-like threads through the narrow end (*Figure 3*); Frey Wyssling and lutoid particles are seen similarly attached to threads. These observations suggest that the particles may in fact be built up on a reticulum of the thread-like material which forms part of the cytoplasm of the latex vessel.

A particularly interesting observation is that zone 2 separated by high speed centrifuging (see *Figure 1*), which is a jelly-like translucent material containing threads, contains 80 per cent of rubber in the form of exceedingly small particles; it also shows positive reactions for ribonucleic acid. Investigations are continuing on this interesting material which may be associated with the final stages of rubber synthesis.

The thread-like structures described above have also been studied using time lapse photomicrography. They are very fine, being at the extreme limit of visibi-

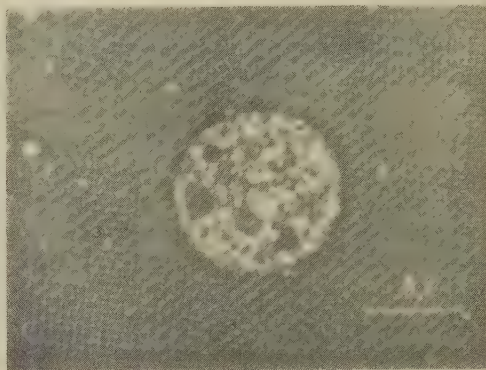


Figure 2. Lutoid particle from latex of Hevea brasiliensis



Figure 3. Rubber particles attached to threads from Hevea brasiliensis latex.

lity by the light microscope but on occasions short threads have been seen to swell, and are then found to be tubes, within which moving particles can sometimes be observed.

Studies on Bark Sections

To assess whether important changes occur in latex after it leaves the tree, attempts were made to see whether the different particles and structures observed so far, could be identified whilst still within the latex vessel. Examination of sectioned latex vessels from the bark revealed rubber particles, cell nuclei, lutoids with interior particles and clusters of Frey-Wyssling particles *in situ*, apparently identical with those seen in excised latex. Thread-like structures were also observed, resembling those seen in latex; these were associated with the nuclei, which appeared to be connected to the vessel wall by a web of threads.

The walls of the latex vessel are lined by a membrane which is easily detached from them. It has been found that this membrane together with some of its contents can be withdrawn intact from a bark section by centrifuging at high speed in such a way that the axes of the latex vessels are in line with the centrifugal field. The membranes appear as collapsed tubes containing nuclei and other components and can be examined under much more favourable optical conditions than when embedded in other tissue.

Latex from Material Other than Hevea Species

It was suspected that many of the particles and structures seen in latex from *Hevea brasiliensis* would be observable in latex from other plant sources. A brief survey of fresh latex preparations made from latex-bearing plants near at hand was undertaken, and included:

- | | |
|---|---|
| (1) <i>Carica papaya</i> (Caricaceae) | (5) <i>Artocarpus integrifolia</i> (Urticaceae) |
| (2) <i>Cerbera lacteria</i> (Apocynaceae) | (6) <i>Ficus hispida</i> (Urticaceae) |
| (3) <i>Allamanda cathartica</i> (Apocynaceae) | (7) <i>Pterocarpus indicus</i> (Legume) |
| (4) <i>Plumeria accuminata</i> (Apocynaceae) | (8) <i>Jatropha podagrica</i> (Euphorbiaceae) |

In five of these preparations vacuolar particles showing morphology analogous to lutoids of *Hevea* latex were observed (Figure 4). In four of these thread-like structures were found, both free and associated with particles.

This work is outside the main scope of the Chemical Division and is not being pursued; nevertheless it seems important to establish that the phenomena observed in latex from *Hevea brasiliensis* are not unique but are common in lactiferous plants.

Rheology

Arising from discussions on yield stimulation and growth factors held at the time of the Natural Rubber Research Conference, Kuala Lum-

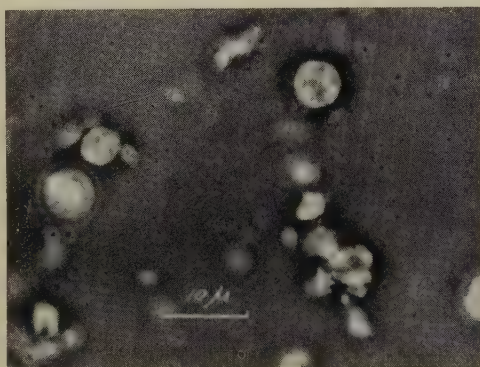


Figure 4. 'Lutoid' type particles from latex of *Cerbera lacteria*.

pur, it was agreed that the Chemical Division should examine the possibility of making a variable shear micro-viscometer, on the lines of the Couette instrument, to investigate flow characteristics of latex from yield stimulated trees. The instrument has been constructed and handed over to Botanical Division for experimental work.

POLYMER CHEMISTRY

Reactive Centres in Fresh Rubber

Further studies on the reactive centres in fresh rubber have added to the existing evidence which indicated that these were aldehyde groups. It has been shown that to saturate the groups so that no cross-linking occurs in the rubber on heating in vacuum the required stoichiometric proportions of hydroxylamine and dimedone (5,5 dimethyl cyclohexane 1,3 dione) are utilised.

The number of aldehyde groups per molecule of rubber hydrocarbon has been assessed by determining the amount of hydroxylamine or of dimedone required to react with rubber hydrocarbon from different sources. The results agree well, and indicate from 9 to 30 aldehyde groups for each molecule of rubber. Expressing this as an average, it indicates one aldehyde group for every seven hundred isoprene units. On the basis of this evidence it is apparent that natural rubber can no longer be regarded as simple *cis* 1:4 polyisoprene, but contains aldehyde groups attached at intervals along the chain.

The reaction between fresh rubber and bi-functional amines has been examined further. It has been shown that whereas at low concentration of diamines hardening occurs, presumably due to cross linking between two aldehyde groups by one diamine molecule, higher levels of the amines give no increase in hardness, cross-linking being prevented since all the active aldehyde groups are reacted with the first amine group of the diamine.

Hardening of rubber during transport is now thought to be due to the activity of aldehyde groups, which may undergo a condensation reaction with labile hydrogen from neighbouring molecules thus forming cross-links. The hardening of rubber on storage has now been inhibited by treatment with monofunctional carbonyl reagents which condense with the aldehyde groups, thus rendering them inactive. Trial shipments to England of smoked sheet treated with suitable primary amines showed no change in Mooney viscosity on arrival at destination. The technical characteristics of such rubbers have yet to be investigated.

SP Rubbers — New Types

The effect of various additives to rubber has now been examined in respect of conferring superior processing (SP) characteristics. A number of materials were found quite effective, including casein, gelatin, solka floc, wood flour, and polyvinyl alcohol. Of these casein presented the best overall possibilities for a cheap form of SP rubber and a mixture of equal parts rubber and casein has been studied in some detail. When mixed with smoked sheet, this masterbatch confers extrusion swell and mill shrinkage characteristics comparable with those conferred by PA 80. Surface finish and physical properties of the final vulcanisate are, however, not so good as in PA 80. On the other hand post-preparational changes and compatibility with other rubbers at present show in favour of the casein masterbatch, which has been designated CA 50. The tear strength of rubbers containing CA 50 is not

high, but may be considerably improved by compounding with paraformaldehyde. Treatment of the sheets with formalin at the time of preparation also gives improved tear strength, although the improvement is less marked. Factory evaluation of this new member of the SP family has yet to be completed.

The possibility of incorporating oil into PA 80 is being examined; it is hoped that this may serve a two-fold purpose by lowering Mooney viscosity, which some consumers consider high, and by reducing cost of production.

Graft Polymers

The observation that fresh rubber can be readily activated to form graft polymers has now been carried a step further in an attempt to round off the present stage of our work in this field. It has been shown that by using a multi-stage grafting process as against a single stage, the number of polymer side chains added to the main rubber hydrocarbon 'backbone', and hence their chain length, can be controlled within certain limits. The effect of more and shorter side chains of methyl methacrylate attached to the rubber molecule has been ascertained and as was to be expected gave tougher and harder products. *Table 14* below compares properties of two methyl methacrylate grafts, one with 40 parts of added polymer, (MG 40), by a multi-stage process giving many short side chains, the other with 50 parts of polymer, (MG 50), prepared by a single-stage process and having fewer, longer side chains.

TABLE 14. PHYSICAL PROPERTIES OF GRAFT RUBBERS

Sample	Stages	Tensile strength Kg/cm ²	Modulus 100% Kg/cm ²	Elongation at break %	Hardness B.S.I.°
MG 40	1	218	80	327	96
	10	227	113	317	98.5
MG 50	1	134	114	136	99

It will be noted that a tougher rubber is produced by the multi-stage process, for a given proportion of added polymer, and that MG 40 multi-stage is as tough and hard as MG 50 single-stage, with the added advantage of greatly increased (twice to three times) extensibility and of course higher tension strength.

A small amount of interest has been shown by consumers in these new graft polymers, the study of which is perhaps of more value in an academic sense since they expand our understanding of methods for modifying the properties of natural rubber.

Drying of Coagulum

No further investigations have been undertaken on the drying rates of sheet rubber, but the main findings on the relationship between drying time and temperature, humidity of drying air and sheet thickness have been summarised and published in the form of a nomograph.

Experimental work on the cause of blister formation has been extended to include bubble formation. The effects of temperature, humidity and sheet thickness are the same as for blister formation and the two defects are considered to arise through the same mechanism. Serum expressed from sheet during machining contains carbon dioxide and hydrogen sulphide (originating largely from putrefactive changes) each of which can be liberated from solution by stirring. Gas contained in the serum remaining in the sheet at the start of drying is responsible for the formation of bubbles and blisters as drying proceeds.

Whether minute bubbles are present in the coagulum before drying commences depends upon the concentration of gas in the serum phase. The concentration is influenced by the pH value of the serum and by the amount and type of anticoagulant present. In extreme cases gas bubbles form in the coagulum before drying commences. Methods of reducing the incidence of bubbles and blisters include the following: suppression of gas formation by the use of suitable anti-coagulants and coagulating conditions, reduction of sheet thickness, and drying under conditions which favour the release of gas by slow diffusion, for instance using a high humidity during the initial stages of drying (*Figure 5*).

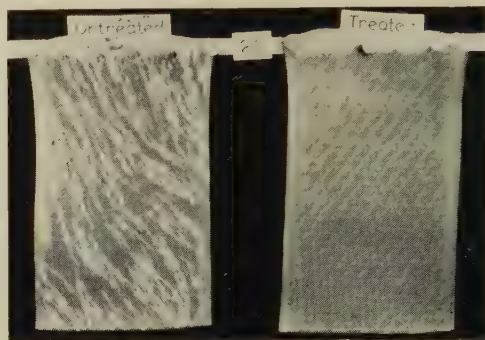


Figure 5. An initial high humidity treatment (for four hours) before drying at low humidity has eliminated bubbles in sheets prepared from coagulum 2.0 inches thick and dried at 140°F.

APPLIED RESEARCH AND TECHNOLOGY

LATEX TECHNOLOGY

Preservation

Preservation trials examining a large variety of substances in combination with low levels of ammonia (0.2 per cent) have continued during the year. Members of the following groups of substances have been found satisfactory from the point of view of maintaining desirable values for V.F.A., KOH Number, mechanical stability and viable bacterial count:

- Chlorinated and alkylated phenols
- Bisphenols
- 8-hydroxyquinoline and derivatives
- Dithiocarbamates
- Thiazole accelerators of vulcanisation
- Organic oxides and peroxides

These materials are good preservatives when used with ammonia, with ammonia/boric acid or with ammonia/zinc oxide combinations and often show synergistic effects with zinc oxide in the last named systems. Trials with Hibitane,

(chlorohexidine) Lissapol N, (polyether) Vantoc B, (tetradecyl pyridinium bromide) sorbic acid, zinc mercaptoimidazole, Dettol (mixed chlorinated xylenols) and phenyl beta-naphthylamine showed these materials to be unsatisfactory.

The evaluation of possible preservatives for latex concentrate preparation is lengthy and time consuming. Attempts have therefore been made to establish a rapid screening test by which the less effective reagents would be sorted out. Experiments measuring rate of kill of bacteria produced by the bactericide when added to latex have shown that a reasonable correlation exists between rate of kill in field latex containing 0.3 per cent ammonia and preservation of properties in latex concentrate stored for periods of up to six months. Measurement of rate of kill in concentrate containing 0.2 per cent ammonia to which a standard inoculum had been added showed no correlation with preservation on storage. Further experimental data are obviously required before rate of kill can be used as a screening test for preservatives, but the method is considered promising.

Effect of Manuring on Latex Properties

Two experiments are in progress on commercial estates to study the effect of manurial treatment upon analytical and technological characteristics of the latex.

A complete statistical analysis of the data collected will not be undertaken until the trials are further advanced, but indications at present are that contents of nitrogen, phosphorus and potassium in the latex are each increased by manurial treatment containing the element in question.

In one trial seasonal changes have had a definite influence upon the magnesium content of latex from clone PB 86, which is normally high. For two successive years there has been a sharp reduction in magnesium content and a corresponding increase in mechanical stability during the period February to April. Observations on latex collected in the other trial, based on clone RRIM 501, show only slight, irregular variation in magnesium content; similar slight seasonal variations have been observed in experiments on our own station at Sungei Buloh for RRIM 501, Tjir 1 and a group of mixed seedling trees.

Clonal Latices

Latices from more than forty different clones, mainly of the RRIM 500 and 600 series, on commercial estates have been re-examined for suitability in preparing latex concentrate. In most cases satisfactory results were obtained, but after three months' storage latices of the following clones were found to have low mechanical stability: RRIM 527, 616, 618, 621, 626, 627 and 629, S.G 161, PB T495, PB 28/83, PB 5/76, PB T159, PR 107, and Tjir 1. It should be borne in mind that mechanical stability is a characteristic dependent upon location so that the above clones may yield better results in a different environment. Even so, the above-named clones may require special care on this account.

Specific Gravity of Latex

Inadequate data is available concerning the effect of temperature on specific gravity of preserved latex concentrate and we have been approached a number of times to undertake an investigation of this problem. Experimental work has now established a significant relationship between specific gravity and temperature

for latex at a d.r.c. of 60.10 per cent, representing the mean of a large number of concentrates examined, which may be expressed as follows:—

$$S_t^t = 0.952364 - 0.000301257 t,$$

where S_t^t is specific gravity at any temperature $t^\circ\text{C}$.

Within the narrow range of d.r.c. studied, 59.95% to 61.00%, no statistically significant effect of d.r.c. on specific gravity was proven, although a trend for decrease in specific gravity with increase in d.r.c. was indicated. A closer study of the specific gravity/d.r.c. relationship at different temperatures is now being made.

Rubber Latex Foam

Work on rubber latex foam was undertaken to establish evaluation procedures for new types of preserved latices, which are assessed both for processability in preparing foam and for physical characteristics of the final product. In order to distinguish between not very dissimilar latices, it was necessary to develop specially sensitive test procedures for stress-strain relations. Test results were of course dependent upon the bulk density of the foam and since this could not be controlled precisely during preparation, appropriate corrections for density had to be applied to the test data.

It was observed that a relationship existed between density and compression modulus over a wide range of density values. This has been assessed for a number of different foams and was found to hold good under a wide range of conditions. It can be expressed in general terms as follows:

$$C = A.d^n,$$

where C is the compression modulus, d the density and A and n are constants for a particular latex and formulation for vulcanising. For all foams examined so far n has a value of about 2.5.

This relationship is of considerable value in determining compression modulus, since only two determinations at a known density need be made for a given latex compound under standard preparational and vulcanisation conditions. Values at other densities can be calculated from the formula. In our work, where different latices have to be compared, this has resulted in saving much time and labour.

RUBBER TECHNOLOGY

Superior Processing (SP) Rubber

A considerable effort has been made to ensure satisfactory quality control of SP rubber production on estates. The introduction of control charts for each factory has been of considerable value in indicating lapses in quality and enabling suitable corrective measures to be recommended. Work with the mill-shrinkage test to replace the present die-extrusion test is nearly completed and it is hoped to establish the new test for routine work during 1961.

The effect of storing vulcanised latex for periods up to fourteen days before preparing SP sheet was shown to be negligible. Comparison of rate of breakdown on milling for SP sheet and SP pale crepe shows them to be the same.

It has been established that when prepared from the same latex the tear strength of SP rubbers is higher than that given by the corresponding trade grade, provided the rubbers are compounded with normal amounts of vulcanising ingredients. If the amount is reduced for SP rubber in proportion to the amount of pre-vulcanised rubber present, tear strength is lowered and may fall below the value for the corresponding trade grade.

Tests on different consignments of commercially prepared PA 80 showed that the Mooney viscosity of the raw rubber did not vary significantly. Post-preparational changes, however, can give rise to cross-linking in the raw rubber matrix during storage, with consequent increase in Mooney value; attempts to establish a correlation between increase in viscosity and free sulphur were not successful.

Low Grade Rubbers

An examination of more than 350 samples of brown crepe from one estate has shown that the 3X crepes differ significantly from 1X and 2X in respect of both raw and vulcanised rubber characteristics.

Similar conclusions were drawn from a less detailed but broader and statistically planned survey, in which forty-eight samples collected from eight estates were examined for physical and chemical characteristics. For most properties 1X and 2X crepes were on the average better than 3X crepes, but it was not possible to specify critical values which would permit clear demarcation of the three grades for fourteen out of the fifteen chemical and physical properties examined. The exception was ash content.

Rubbers Containing High Non-Rubber Constituents

A series of rubbers have been prepared by different methods such as evaporation, coagulation at field d.r.c., coagulation after concentration by centrifuging, to study the effect of changing the content of non-rubber constituents upon technological characteristics.

Only small differences in rate of breakdown on milling were observed, but marked differences in rate of cure were found; the higher the proportion of non-rubbers the quicker was the rate of cure. Technological properties of the rubbers in gum and tread stocks showed differences in properties, such as modulus, tension strength, and resilience, but none of the rubbers behaved so abnormally as to render them unacceptable for normal consumption by industry, save perhaps in respect of high rate of cure. Further work with modified preparational methods is in hand with a view to reducing the scorchiness of rubbers with a high non-rubber content.

Preparation of satisfactory rubbers containing more non-rubber constituents than smoked sheet would offer an advantage to producers in the shape of a higher yield from a given volume of latex. Preliminary trials in which the rubbers were blended with synthetic rubbers suggest that a further advantage may be gained since these rubbers appeared in some cases to confer better characteristics on the blend than does smoked sheet, at least in gum stocks. A much fuller investigation of the problem must be carried out, however, before any conclusions can be drawn.

PROCESS EVALUATION AND FACTORY STUDIES

LABORATORY AND DESIGN STUDIES

Economics of Sheet Manufacture

a. *Drying.* For a drying tunnel working at constant relative humidity there is an optimum value at which total cost of drying is a minimum. Whilst this has been obvious for some time, the value for optimum humidity has not been estimated. Detailed calculations based on our recent studies of the effects of temperature and humidity and utilising current costs of drying tunnels and equipment now indicate that the optimum is about 40% R.H. Increase in the temperature of drying at optimum relative humidity has little effect on running costs, but lowers the capital charge since size of drier for a given output is reduced.

There are difficulties, however, in taking practical advantage of the reduced cost of higher temperature drying. In the first place bubble and blister formation is increased and secondly it becomes more difficult, as the temperature is raised, to maintain relative humidity at the comparatively high optimum level required since the volume of drying air required is less and the effect of leakage becomes greater.

Experimental work on the mechanism of bubble and blister formation suggests that the problem may be overcome by suitable drier design. Such a design is being used for the new oil-fired drier to be erected shortly at Sungei Buloh, which will also permit the studies of methods to overcome the second difficulty mentioned above.

b. *Coagulation and machining.* Our studies on drying have shown that the thinner the sheet the lower is the cost of drying. By halving thickness, the number of sheets is doubled but the rate of drying is almost quadrupled; the size of drier required for a given output is thus approximately halved. Various means are available for halving sheet thickness, such as halving partition plate spacing or halving d.r.c. of coagulation. Both methods, however, involve increased expense in extra labour for machining, loading, grading and packing; halving the d.r.c. would also mean doubling the requirement of coagulating tanks and more extra labour. Unfortunately the saving in cost to the drying operation is more than offset by the increased expense involved in reducing sheet thickness.

The above argument assumes the same intensity of machining for thin as for thick sheets. However, if coagulum is made thinner by greater intensity of the machining operation an advantage in drying should be obtained with no extra charges for coagulation, handling, packing, etc. Since the present charges for machining, both capital and operational, are only a fraction of those for drying, the possibility of developing machines to give greater thinning of the coagulum appears worthy of future study.

Experimental Oil-fired Drier

The first design for an experimental oil-fired drying tunnel has been completed and its construction ordered at the R.R.I. Experiment Station. The design is based upon principles of drying established in our laboratory investigations and will be used to investigate two stage drying and high temperature operation at a commercial level.

Pasteurisation of Latex

The possibility of pasteurising latex with a view to reducing bacterial contamination and thus preserving it against putrefaction, has been examined from the economic standpoint. Using data available from the pasteurising of milk, it has been estimated that the cost would be 1.0 cent a pound of dry rubber for field latex and 0.5 cent for latex concentrate.

Pasteurisation gives only a fractional reduction of the bacterial population and not complete sterilisation; it is particularly suitable for removing pathogenic species. The use of bactericides would therefore be a necessary supplement to such treatment for satisfactory preservation of latex, although the amount required is likely to be less than that normally used. A disadvantage of such a process for preserving latex is that it provides inadequate safeguard against contamination occurring after the pasteurising treatment.

The cost of pasteurisation is high compared with the current cost of preservation (which in the case of ammonia is about 0.7 cent per pound of dry rubber) and would add considerably to the cost of producing latex concentrate. It would thus appear more economic to invest in more powerful bactericidal systems than to adopt pasteurisation as an aid to latex preservation.

Recovery of Ammonia from Latex Skim

Our studies on the recovery of ammonia from latex skim have made good progress. Trials with a five-foot-long steam-stripping distillation column were satisfactory and overcame the technical difficulties experienced in earlier trials using batch distillation. There was no significant difference between the vapour/liquid equilibrium for pure ammonia solutions and for latex skim. It is concluded that ammonia can readily be removed from latex skim, over 90% being recoverable. Fouling of the column has been unexpectedly small.

The skim after de-ammoniation coagulates readily and at a higher pH than normal skim, thus giving a further saving of acid consumption beyond the reduction obtained by removing ammonia. The properties of the skim rubber obtained are good and no deterioration in respect of colour, ageing properties or copper content was produced.

No experimental figures for the cost of recovering ammonia are yet available. The type of packing used in the column (locally made Raschig rings) readily gave rise to foaming, thus limiting the rate of throughput. It was also found that when using ammonia solution the column was equivalent to about four theoretical plates, which was less than the six theoretical plates shown by design study to be the optimum number. When using latex skim the number was even lower, being about 2.5. These differences are thought to be due to peculiarities in flow characteristics of latex skim and are probably related to the type of packing employed. It is apparent that to get the process working efficiently further trials with improved column packings should be undertaken.

LARGER SCALE INVESTIGATIONS

New Double 'B' Smokehouse

Construction of the new double 'B' smokehouse at R.R.I.E.S. has almost been completed (*Figure 6*). The first tunnel was ready for service by the middle of the year and has been in continuous operation since then.

Structurally the smokehouse has stood up to operating conditions very satisfactorily. The furnace is of revised design and has given good service; a number of similar type have already been installed on estates.



Figure 6. RRIM Double 'B' type smokehouse recently constructed at Sungei Buloh. Several improved features have been incorporated.

Details of operation to give maximum efficiency have been worked out and are available to producers from the Chemical Division Advisory Service. With four day drying the single type 'B' tunnel is giving an output of 3,000 lb a day, when drying sheets from 18 in. coagulating tanks on beroties with a clear hanging length of 6 ft; the nominal rating is of course, 2,000 lb a day.

Drying of PA 80

The drying of PA 80 is normally carried out on wire mesh trays, two or three inches deep, supported on trucks which can be wheeled into standard air drying sheds. Drying requires one or two days and the product obtained is a loose crumb. An improved method has been studied in the laboratory and is now being developed for commercial use.

Preliminary calculations show that for drying at 100°F, a bed depth of 12 to 15 inches and an air speed of 100 feet a minute is a suitable combination to give minimum operating costs. The possibility of higher temperature operation has yet to be investigated.

Trials of the method are being conducted in co-operation with estates producing PA 80. Drying occurs in about eight hours; the product consists of a loosely coherent block which can be handled, and if required can be produced in an appropriate size for direct insertion into the baling box, where it is compressed to a solid block ready for packing.

This system of drying could of course be applied to any form of rubber produced in a particulate form, such as crumb, flocculated rubber, diced coagulum, etc.

Effluent Disposal

It has now been established that trickling filtration can be used to bring about a marked reduction in the degree of pollution of effluent discharged from rubber and latex factories. The requirements for optimum efficiency have not yet been fully worked out and at present it appears likely that they will usually depend on local conditions.

The efficiency in reducing B.O.D. (biological oxygen demand) for diluted skim serum in a trickling filter is reduced when the organic loading is increased. Thus if the proportion of treated effluent recycled through the bed is increased or if the organic load is increased by adding new liquor, the efficiency drops. For a wide range of effluent strengths (700 to 5,000 p.p.m. B.O.D.) and recirculation ratios from 0 to 45 the relation can be expressed by a single correlation.

$$P_0 = 74.64 - 21.60 \log_{10} B^1,$$

where B^1 is the true organic loading in pounds B.O.D. per 1,000 cubic feet of filter bed per day, and P_0 is the percentage removal of B.O.D.

Although the percentage removed, P_0 , drops with increased organic loading, the total B.O.D. removed for a given unit of filter bed increases. Thus both recirculation of liquor and increasing the strength of the raw effluent result in a more effective use of the filter bed. Recycling has the drawback of increasing costs, but has the advantage of increasing the hydraulic load which reduces the chances of clogging the bed.

The above results apply to a bed that is working satisfactorily. If the organic loading is increased beyond a certain point, micro-organisms in the filter proliferate so rapidly and clog the interstices between the stones, a phenomenon known as 'ponding'.

Ponding is the main factor limiting an increase in organic loading and part of our present effort is directed towards finding means of reducing its onset.

A standard method employed in effluent disposal systems is pre-treatment of the liquor with flocculating agents such as ferric chloride and lime. In our trials this has so far not proved to be of much value and is now being omitted, the factory waste being delivered directly to the bed.

A second filter bed has now been constructed alongside the first one and our present trials are aimed at comparison of different methods of operation, including series and alternate double filtration.

Production of Special Rubbers

The manufacture of special rubbers has continued at our Experiment Station factory, new materials being produced for consumer evaluation; the better established types were prepared only when market demands could not be met by commercial producers. Production and shipments are recorded in *Table 15*.

TABLE 15. PRODUCTION AND SHIPMENT OF SPECIAL RUBBERS

Type	Amount produced, lb	Amount shipped, lb
SP RSS	71,723	94,738
SP brown	64,007	62,940
PA 80	187,697	171,380
MG 49	600	500
MG 30	750	624
CA 50	100	75

Full scale production of PA 80 rubber began at the Experiment Station in January, and has continued throughout the year, supplementing commercial production as required during the last half year.

Only small quantities of methyl methacrylate graft rubbers (MG 30 and MG 49) were prepared, in response to requests from consumers in Great Britain, Australia and Japan.

ADVISORY AND TECHNICAL SERVICES

Apart from its activities in the fields of research and development, Chemical Division carries out a considerable volume of routine laboratory and advisory work, the latter often leading to small *ad hoc* investigations.

Routine testing is carried out on behalf of the Botanical and Soils Divisions, and the Experiment Station factory, as well as on behalf of outside estates and factories, the Smallholders' Advisory Service, rubber manufacturers, and Government and Municipal authorities. During 1960 it is estimated that just over 45 per cent of the manpower in the Analytical Section was devoted to this work. A similar situation obtains for latex testing. A large number of samples of special rubbers are received from estates for routine technological testing in connection with quality control of production. In addition to this service to estates, the Rubber Technologist spends approximately half his time on technical services to manufacturers.

Our work in these advisory fields links with the technical service carried out in Great Britain by the Natural Rubber Producers' Association and in the U.S.A. and other countries by the Natural Rubber Bureau offices. We deal directly with technical enquiries from Far Eastern countries, such as Japan, South East Asia, India, referring problems to our colleagues overseas when necessary. They likewise refer to us complaints in quality and other production problems, made by consumers of rubber and latex.

The account of our activities during 1960 is presented below and concerns:

- a. Chemical Division Advisory Service to Estates
- b. Technical Classification of Rubber
- c. Technical Service to Rubber Manufacturers

CHEMICAL DIVISION ADVISORY SERVICE TO ESTATES

There has been a considerable increase in the volume of requests from the industry for assistance with problems dealt with by our Advisory Service. Enquiries by letter and interviews at Headquarters both show an increase of well over fifteen per cent above the 1959 level. Nearly 5,000 letters were received and over 5,000 dispatched in 1960. There were 260 advisory and 103 research and other visits to estates. Five hundred and eight interviews were given. One lecture was given to a branch of the Incorporated Society of Planters. Over 23,000 estate samples of various kinds were examined.

Sheet Production

Interest in sheet production increased during the year, largely owing to increasing yields from new plantings and a reduction in the amount of latex required for concentrate production. Lay-outs for sites and factories were prepared for several estates.

The most common problem met with in sheet manufacture was the appearance of bubbles. This difficulty arises when sheet is too thick, the pH of coagulation too high, or when conditions in the drying shed are too hot or too dry during the early stages. Bubbles arise from bacterial processes and can often be overcome by treating latex with formalin before coagulation. The use of a lower pH of coagulation also assists, partly by reducing bacterial activity and partly by enabling any gas formed to escape more readily before coagulation sets in. The question of pH is not quite straightforward since it is not always possible to assess the acidity of the latex on the basis of the amount of acid added. Thus on one estate the amount of formic acid required to coagulate two different latices at pH 4.7 was found to be one ounce to 12 pounds of dry rubber and one ounce to 22 pounds respectively, no anticoagulant being used in either case. A determination of the actual acidity of the latex after adding the coagulant is thus the only reliable means of assessment.

More estates have invested in oil-fired drying tunnels and some have installed the modified R.R.I. type smokehouse, based on the one built earlier in the year at our Experiment Station. Both types give satisfactory results when operated as prescribed and are relatively easy to control.

A number of enquiries have been received respecting the use of patented additives for producing 'smoked' sheet rubber without smoking. The use of such processes is not attractive to large estates but may find application to smallholders' production. Preparation of rubber in this way has not developed rapidly since such sheet has not been recognised as a standard market grade. At the recent conference on packing and quality in Singapore, however, it was agreed to amend the 'Green Book' specifications to include such products under the heading of air dried sheets similar in colour to smoked sheet.

Crepe Production

During the year the premium for pale crepe above RSS 1 has often been less than the extra cost of production involved and only a few enquiries were received from estates concerning new facilities for production. Problems arising mainly concerned discolouration before or after packing and difficulties in lamination for sole crepe preparation. The R.R.I. bleaching system using Emulsion A concentrate continues to be popular; from the amount of bleaching agent consumed it is estimated that at least 20,000 tons of pale and sole crepe were produced during the year by this method.

The production of many remilling factories has increased since 1959 owing to increased availability of imported scrap rubber. The imported material appears to be of poor quality and it is interesting to record that several remillers in port areas have discussed with us means of improving quality in the remilled crepe. Brown crepe production at inland centres depends more on locally obtained scrap and these centres have been affected much less.

Latex Concentrate and Skim Rubber

During 1960, the demand for latex concentrate dropped, particularly during the second half of the year, and production was reduced in many large factories, in some cases ceasing altogether. Even so, exports during the first eight months were only two per cent less than for the corresponding period during 1959.

Very few complaints were received from consumers and most producers now have production and shipping processes under good control as regards hygiene and bacterial spoilage.

Low ammonia latices continue to be popular with some consumers, but the proportion of concentrate produced in this form has not changed much during the year.

Boric acid latex was prepared and shipped by seven producers to twelve different countries, the total amount exported being about 15 per cent less than in 1959, but still representing over 3,300 tons of dry rubber. Most producers include a small amount of a third bactericide in boric acid latices. In the majority of latex producing factories, latex skim is now converted to a thick, light coloured crepe, for which there is now a considerable demand. Deproteinising processes designed to yield a more pure rubber are not generally used, being somewhat unpopular because they offer a lower return to the producer. Since ways of utilising the special properties of skim rubbers have been publicised by the producers' research and development organisations, consumers are taking advantage of them and it is hoped that difficulties in marketing this material will not be experienced again.

Special Types of Rubber

Special rubbers based upon processes developed at the Institute continue to be produced in Malaya in commercial quantities, the factories concerned submitting samples for examination in our laboratories to maintain control of quality. *Table 16* shows the types and quantities of rubber produced.

TABLE 16. COMMERCIAL SHIPMENTS OF SPECIAL RUBBERS BASED ON R.R.I.M. PROCESSES, 1960

Type	Shipments in tons
SP RSS	1,853
SP pale crepe	330
SP ADS	20
SP brown crepe	415
PA 80	210
Partially purified crepe	260
Cyclised rubber	53

The figures show an increase in total shipments of SP rubbers over that for the previous year, being 2,828 tons as compared with 2,316 tons in 1959. *Figure 7* shows half-yearly shipments for 1956-60. The rubbers were shipped to 23 consumer countries, the largest consumers being Great Britain, the U.S.A., Japan and New Zealand. Requirements for SP sheet and pale crepe fell throughout the year, whereas those for brown crepe steadily increased. Commercial production of PA 80, the concentrated form of SP rubber for mixing with any grade of rubber, natural or synthetic, was commenced during the early part of the year and 200 tons were produced; owing to the concentrated form of PA 80 this figure is equivalent to over 800 tons of normal SP rubber.

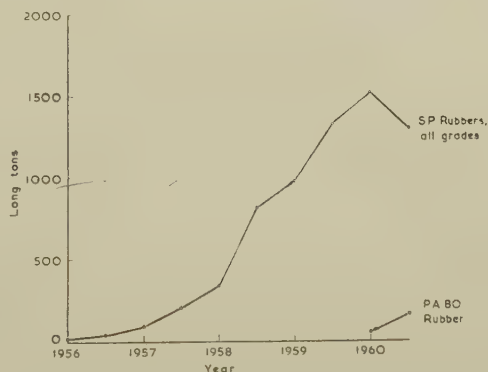


Figure 7. Half-yearly commercial shipments of SP rubbers from Malaya 1956-60.

During the year sixteen different estates have been concerned in the manufacture of SP type rubber.

A considerable effort has been expended in developing a satisfactory means for controlling estate production of SP and PA 80 rubbers. A control chart system introduced during 1959 has proved very useful in indicating lapses in quality as soon as they occur, so that corrective measures can be taken at an early stage.

Regular commercial production of partially purified crepe is now well-established. Earlier difficulties with brown and grey discolouration have been overcome.

Technical Classification of Rubber

Production of Technically Classified Rubber has remained at about the same level during the past three years; 1960 total production is estimated to be a little higher, at 30,216 tons, than the corresponding figures for 1958 and 1959, which

were 29,619 tons and 28,880 tons respectively. Most of the rubber classified came from estates, packing-house production being only 381 tons, as compared with 407 tons in 1959.

The number of estates co-operating during the year was 69, as compared with 70 last year; thirteen estates withdrew and twelve new estates joined the scheme.

Details of estimated production for estates in the Federation of Malaya and British North Borneo are given in *Table 17*.

TABLE 17. ESTIMATED OUTPUT IN LONG TONS OF RUBBER FROM ESTATES USING R.R.I. FACILITIES FOR TECHNICAL TESTING *

Type	Technical classification			
	Red Circle	Yellow Circle	Blue Circle	Total
Int. No. 1 RSS	332	19,431	5,062	24,825
Int. No. 2 RSS	—	50	—	50
Clippings	—	30	—	30
Pale crepe	328	—	—	328
Brown crepe	—	—	86	86
ADS	512	3,694	310	4,516
<i>Total</i>	1,172	23,205	5,458	29,835

* Including production from British North Borneo and from Socfin Company.

Five different packing houses requested classification of their produce, the amounts involved being as shown in *Table 18*.

TABLE 18. RUBBER FROM PACKING HOUSES CLASSIFIED AT R.R.I., LONG TONS

Type	Technical classification			
	Red Circle	Yellow Circle	Blue Circle	Total
Int. No. 1 RSS	—	263	30	293
Brown crepe	—	88	—	88
<i>Total</i>	—	351	30	381

The Division has continued to act as technical co-ordinator for the international activities of the Scheme for Technical Classification of Rubber, under the auspices of the International Rubber Research and Development Board. Laboratory cross-checks have been carried out with test stations in other producing territories, one series covering nine stations in five countries and another covering seven stations in co-operation with the International Standards Organisation. In November–December the R.R.I.M. Officer in charge of Technical Classification made an official visit to Indonesia, to make contact with testing stations in Java and to advise on production and testing of TC rubber.

Technical Bulletin No. 39 which was issued in June, gave details of world TC rubber production and a review of the activities of the Scheme during the period 1955 to 1959.

Consumer interest in TC rubber is still confined largely to the smaller factories. We have received reports of difficulties in obtaining supplies, however, from a number of sources and also of difficulties arising from improper use of the TC bale mark. During the year we therefore commenced circulation of a list of *bona fide* estates from which supplies of TC rubber can be obtained; this is now circulated every quarter to consumers by way of the N.R.B. offices and in Japan through the courtesy of the Foundation for Natural Rubber Research and Development.

Technical Service to Rubber Manufacturers

Our Technical Service to Malayan rubber manufacturers has now been in operation for just over one year. There has been a marked increase in the volume of technical enquiries received, most of which originated in the Federation and Singapore, others came from India, the Philippines, Sarawak and Japan.

During the year seventy-five visits were paid to factories throughout Malaya, and the response has been enthusiastic, as will be seen from the records shown in *Table 19*.

TABLE 19. ENQUIRIES FOR TECHNICAL SERVICE

Organisation	Paper work	Laboratory work
Rubber manufacturers	28	57
Government, Municipal Departments, etc. ...	7	7
Industrial concerns other than rubber	4	7
Overseas	23	5
Miscellaneous	—	2
<i>Total</i>	62	78

One of the major problems dealt with was extra light microcellular soling. Retreading compounds and retreading practice have also received a great deal of attention; in many instances we have been successful in replacing obsolete compounds and methods by more up-to-date ones. In one case a new retreading plant has been erected following our recommendations.

Other problems studied include shoes for lepers, latex foam and dipping compounds for joint rings, and the use of SP rubbers for which a small steady demand now exists in Malaya.

Liaison. Active liaison has been maintained with N.R.P.R.A. technical service staff in England, as well as with N.R.B. staff in America, Malaya, Australia, New Zealand and South Africa.

The Division continued to provide liaison between the Committee of Malayan Latex Technologists and the British Standards Institution Sub-Committee RUC/10/7, which deals with specifications for latex testing. Contact was also maintained with the International Standards Organisation and with Sub-Committees of the American Society for Testing Materials, Committee D-11, which deal with latex and with raw rubber. Exchange of views was continued with sister Research Institutes and with the International Rubber Research and Development Board.

Exhibitions. Officers of the Division prepared a stand for the Malayan Agricultural and Horticultural Association 1960 Exhibition, on 'Evaluation of Rubber' and a stand for the End of the Emergency Exhibition on 'Superior Processing Rubber'.

W. G. WREN
Head of Chemical Division

Smallholders' Advisory Service Division

The Smallholders' Advisory Service exists to give technical advice, based on the results of research, to rubber smallholders with the object of improving the quantity and quality of rubber produced and, at the same time, the return to the producer. It is the link between the R.R.I. Research Divisions and the small producer. Advice is given through a field staff which maintains close contact with rubber smallholders throughout Malaya. The staff has not been sufficiently large to provide advice to each and every smallholder and the Service has been following a policy of expansion for some years. During late 1959, an *ad hoc* Committee was set up by the Board of the Rubber Research Institute to examine proposals for future expansion of the Service. The *ad hoc* Committee comprised the Director of the R.R.I.M. as chairman, the Hon'ble Inche Abdul Jalil bin Haji Aminudin, J.P., the Hon'ble Mr Yap Kim Hock, J.P. and the Smallholders' Advisory Officer. The second meeting of the Committee was attended also by co-opted members interested in certain items under discussion: the Director of Agriculture, the Chief Replanting Officer, and the Chairman, Boards of Administrators, Government Rubber Replanting Schemes. The report of the *ad hoc* Committee was considered by the Board in August 1960 and its recommendations accepted in principle.

The major recommendations of the Committee concerned the rate of expansion desirable for the Service. The aim will be to provide, by the end of 1963, one Assistant Rubber Instructor to serve each 5,000 acres of smallholders' rubber, with one Rubber Instructor supervising at least six, or more probably eight, Assistant Rubber Instructors. The rate of recruitment will be as rapid as requirements for training permit and the field staff by the end of 1963 will comprise approximately forty Rubber Instructors and three hundred Assistant Rubber Instructors. During 1960, therefore, special efforts have been made towards recruiting and training new staff.

Headquarters Staff

Mr Yeoh Chong Hoe, a graduate of Reading University and the College of Agriculture, Serdang, was appointed Assistant Smallholders' Advisory Officer on 1 November.

Mr Sng Thian Lye was appointed Administrative Assistant on 1 May.

Rubber Instructors

Two promotions to Senior Rubber Instructors were made and five new Rubber Instructors were appointed bringing the cadre at the end of the year to three Senior Rubber Instructors and twenty-one Rubber Instructors.

Assistant Rubber Instructors

The cadre of Assistant Rubber Instructors is the section of the Service which can be most rapidly increased. During the year, fifty-one new appointments were made, but there were ten resignations. The total number of serving Assistant Rubber Instructors at the end of the year was 128, of which 25 were serving on probation.

The number of Assistant Rubber Instructors employed will again be increased during 1961. Applications to attend a training course for prospective new employees were invited at the end of the year.

The rate of resignation among Assistant Rubber Instructors has been high, as S.H.A.S. trained personnel are much sought after by other employers. All new recruits, therefore, are now required to enter into an agreement to serve as Assistant Rubber Instructor for a minimum of three years after their period of training. Since this agreement was introduced the rate of resignations has been very much less and the present rate of wastage must be accepted as inevitable.

Staff Experience

Table 20 shows field staff and their length of service in their present

TABLE 20. EXPERIENCE OF FIELD STAFF AT 31 DECEMBER 1960

Years of Service	0	1	2	3	4	5 or more	Total
Senior Rubber Instructors	2	1	—	—	—	—	3
Rubber Instructors	5	2	3	1	1	9	21
Asst. Rubber Instructors	50	37	12	8	10	11	128
Rubber Demonstrators	—	—	1	—	—	9	10
<i>Total</i>	57	40	16	9	11	29	162

appointments. This demonstrates clearly the deficiency in experienced officers which is the present limiting factor in the rate of expansion of the Service. Only 30% of all field officers have more than two years' service.

Recruitment and Training of Staff

Ten scholarships tenable at the College of Agriculture, Serdang, were awarded to students who were prepared to serve as Rubber Instructors on completion of their College training. Twelve scholarships had been provided but two could not be awarded as only ten places were allocated for R.R.I. scholars at the College. Facilities at the College have, in fact, been the limiting factor in the rate of recruitment of Rubber Instructors since 1951. At 31 December 1960 there were twenty-two R.R.I. scholars at the College of Agriculture. Six are expected to graduate during 1961, six in 1962 and ten in 1963.

Two courses for prospective Assistant Rubber Instructors were attended by a total of 83 students of whom only 55 were prospective recruits to the Service. The others were sponsored by other organisations. Seven serving Assistant Rubber Instructors attended the two courses to assist with supervision of field work and simultaneously to improve their own technical knowledge. These Assistant Rubber Instructors took the examinations at the end of the courses and it was apparent that they had benefited from their attendance. A refresher course attended by twelve serving Assistant Rubber Instructors was conducted at the Smallholders' Rubber School, Ayer Pa'abas from 20 to 23 June inclusive. This was an intensive course and designed not only to cover recent technical developments but also to instruct those attending in extension methods. While it is difficult to assess directly the results of such refresher courses there is no doubt that

they do provide a stimulus to greater efforts by the weaker Assistant Rubber Instructors selected to attend. They are of particular importance while so many Assistant Rubber Instructors lack experience, and further courses will be conducted each year.

ADVISORY

The work of the Smallholders' Advisory Service may be divided into two categories: direct advisory work among smallholders which aims at immediate practical results and the less direct provision of education and information aimed at both immediate and more long term results. The two approaches are complementary to one another and are integrated in practice. Direct advisory work may be undertaken with individual smallholders or with small groups whereas the less direct approach caters for larger groups. Both sections of the work depend upon the personal efforts of Rubber Instructors and Assistant Rubber Instructors but considerable use is made of advisory aids of all types and assistance is often received from other organisations. With a comparatively small staff, work with groups of smallholders has been given priority, but as the field staff increases more attention can be paid to the individual smallholder.

The work of the Service is best illustrated by considering the effort in connection with a single problem or group of problems. One problem of topical importance is the tapping of young trees on smallholders' replantings and new plantings. Here the aim of the Service is to persuade smallholders to tap trees only when they reach the accepted standard of tappability and then to tap them correctly, opening a half spiral cut sloping at the correct angle from high left to low right, at the correct height and tapped to the correct depth. To achieve this object, three approaches have been followed.

First the group approach:

- a. Instruction on opening for tapping, tapping methods and systems, with particular reference to young trees, is given during all training courses.
- b. An illustrated booklet—'Good Tapping' is published in Malay, Chinese and English versions and distributed free of charge by field staff.
- c. A film on tapping, again with emphasis on the timing and method of opening young trees, is shown by mobile units as a basis for lectures.
- d. Copies of a series of five posters on tapping, with captions in Rumi, are issued to all field staff. These are used as illustrations during lectures and then left as a lasting reminder of the important points.
- e. A series of 20 coloured slides on tapping is issued to all Rubber Instructors for use by themselves and Assistant Rubber Instructors with portable battery-operated projectors. With the slides are also issued lecture notes for use by Instructors to ensure that important points are not overlooked.

Second, the individual approach:

- f. A list of all smallholdings receiving the final instalment of the replanting grant is provided to Rubber Instructors by Replanting Officers. Each of these holdings is visited by a Rubber Instructor or Assistant Rubber Instructor for the purpose of making contact with the smallholder and later advising him on the tapping of his trees.

- g. Each Assistant Rubber Instructor has a measuring wire and template and demonstrates correct opening techniques on individual holdings as well as to groups.

A third approach has been to make suggestions to the Rubber Industry (Replanting) Board regarding alterations in grant payments to encourage smallholders, first to maintain their trees well to maturity and, second, to open the trees for tapping only when they are of sufficient size.

The advisory methods detailed above illustrate the means by which the Smallholders' Advisory Service fulfils its function of providing advice to individual smallholders, to groups of smallholders, and to authorities concerned with specific aspects of smallholder development. Similar work is undertaken with all aspects of planting, harvesting and processing smallholders' rubber.

Visits to Smallholdings by Field Staff

Table 21 shows the number of visits made to smallholdings by Rubber Instructors and Assistant Rubber Instructors. During the year 33,487 smallholdings not contacted by the Service during 1959 were visited. During the two years in which all visits to smallholdings have been recorded a total of 56,594 holdings have been visited or approximately 14% of the estimated 400,000 rubber smallholdings in Malaya.

The total number of visits made by field staff to smallholdings showed an increase of 45.5% on the total number of visits made during 1959. First visits to replantings made up 46.8% of the total, to new plantings 37.9% and to mature holdings only 15.3%. Compared with 1959 more visits have been made both to replanted holdings and to new plantings at the expense of mature holdings. This is not undesirable as visits to mature holdings are normally concerned with the improvement of rubber processing only and much work on this subject is undertaken with groups of smallholders rather than on individual holdings.

Visits to holdings previously contacted, during either 1959 or 1960, account for 33% of the total visits made by field staff. The pattern of these subsequent visits is similar to first visits but more follow-up visits are made to replantings and less to mature holdings. Visits to immature holdings must cover all aspects of planting and maintenance and greater numbers of visits are therefore required to both replantings and new plantings. While new planting by individual smallholders decreased slightly during 1960 (most new plantings having been undertaken under organised schemes) replanting continued to be undertaken by individual smallholders with the assistance of the replanting grant and greater numbers of visits were therefore necessary to the small individual replantings.

Planting of Rubber

New planting by individuals. New planting recorded by Rubber Instructors on individual holdings totalled 10,272 acres of which 3,329 acres or 32.4% was planted with clonal seedling material. Details are shown in Table 22.

The acreage planted was less than in 1959 but similar to that in the years immediately preceding. New planting acreages continued to be greatest in Johore and Pahang although the area in both States showed a marked decrease compared with 1959.

TABLE 21. SUMMARY OF VISITS BY RUBBER INSTRUCTORS AND ASSISTANT RUBBER INSTRUCTORS

State	Mature rubber						Replanting						New planting						All plantings				
	First visits			Subsequent visits		Sub-total all visits	%	First visits			Subsequent visits		Sub-total all visits	%	First visits			Subsequent visits		Sub-total all visits	%	All visits	%
	R.I.	A.R.I.	A.R.I.	R.I.	A.R.I.			R.I.	A.R.I.	R.I.	A.R.I.	R.I.			A.R.I.	R.I.	A.R.I.	R.I.	A.R.I.				
Kedah	18	411	7	321		757	14.06	149	1,039	127	761		2,076	38.56	249	1,190	306	806		2,551	47.38	5,384	11.0
Perak	88	313	27	147		575	8.27	517	1,869	390	1,566		4,342	62.44	265	973	239	560		2,037	29.29	6,954	14.2
Selangor	228	745	67	410		1,450	31.25	257	1,565	116	876		2,814	60.65	15	225	23	113		376	8.10	4,640	9.4
N. Sembilan	50	268	42	327		687	9.84	95	1,143	226	1,485		2,949	42.24	263	797	253	2,032		3,345	47.92	6,981	14.2
Malacca	37	406	—	63		506	26.11	65	1,020	—	143		1,228	63.36	25	172	—	7		204	10.53	1,938	3.9
Johore	205	1,055	82	285		1,627	15.47	373	3,829	407	1,126		5,735	54.51	524	1,892	231	511		3,158	30.02	10,520	21.4
Kelantan	2	217	—	9		228	5.01	108	1,511	—	52		1,671	36.72	219	2,221	12	200		2,652	58.27	4,551	9.3
Trengganu	—	199	—	18		217	10.21	—	506	—	6		512	24.08	—	1,193	—	204		1,397	65.71	2,126	4.3
Pahang	288	581	53	111		1,033	17.26	545	1,101	183	256		2,085	34.83	852	1,609	179	228		2,868	47.91	5,986	12.2
Total	916	4,195	278	1,691		7,080	—	2,109	13,583	1,449	6,271		23,412	—	2,412	10,272	1,243	4,661		18,588	—	49,080	99.9
Total first visits	5,111 = 15.3%							15,692 = 46.8%						12,684 = 37.9%									
Total subsequent visits	1,969 = 12.6%							7,720 = 49.5%						5,904 = 37.9%									
Total all visits	7,080 = 14.4%							23,412 = 47.7%						18,588 = 37.9%									

TABLE 22. NEW PLANTING REPORTED BY RUBBER INSTRUCTORS 1960

State	Total	Planted clonal seedlings		Budgrafting on previous plantings
	Acres	Acres	%	Acres
Selangor	—	—	—	9
Negri Sembilan	740	457	61.75	946
Malacca	146	146	100.00	112
Perak	727	578	79.50	442
Johore	2,976	278	9.34	2,866
Pahang	2,850	1,365	47.89	2,746
Kedah/Perlis	1,662	324	19.49	217
Penang/P. Wellesley	—	—	—	—
Kelantan	198	78	39.39	184
Trengganu	973	103	10.58	421
Total	10,272	3,329	32.40	7,943

The use of clonal seedling material showed a marked drop, returning to the proportion recorded during 1958. This was expected as field observations and consideration of the demand for budwood both indicated a distinct trend of increasing budgrafting by smallholders. The continued popularity of budgrafted material in Johore is clear and it is also interesting to note the increased use of this material in Pahang. The same trend is noticeable in Kedah, Perlis and Trengganu but in other States the proportions of new plantings budgrafted and planted with clonal seedling material remain about the same.

Budgrafting on previously planted individual holdings at 7,943 acres continues to indicate that all holdings planted with unselected seedlings are budgrafted in due course.

Block new planting schemes. Most new plantings by smallholders continued to be undertaken within organised schemes for developing blocks of land ranging from a minimum of 250 acres up to 6,000 acres. Those participating in each scheme received a measure of financial assistance which ranged from the new planting grant of \$400/- per acre to loans covering all costs of development. These loans are repayable after the areas come into production.

The larger new planting schemes are those administered by the Federal Land Development Authority which provides loans to settlers developing closely managed schemes. Typically, F.L.D.A. schemes aim at the development of 4,000 acre blocks for later sub-division and alienation as ten-acre smallholdings. Each smallholding comprises six or seven acres of rubber land plus an area for planting with fruit or other crops. A number of the F.L.D.A. schemes already established are smaller than is considered desirable, owing to their having been initiated by other organisations and only later taken over by the Authority. The schemes in which some planting had taken place by December 1960 are shown in *Table 23*.

TABLE 23. NEW PLANTING IN FEDERAL LAND DEVELOPMENT AUTHORITY SCHEMES AT 31 DECEMBER 1960

S t a t e	Scheme	Year of first planting	Total area for agricultural development	Area for rubber planting	Planted ordinary seed for budgrafting	Budgrafted	Planted clonal seedlings
Kedah	Guar Napai	1956	Acres 1,264	Acres 864	Acres 175	Acres —	Acres 243
	Batu Lapan	1956	742	519	352	41	167
	Bukit Tembaga	1957	1,340	917	404	—	483
	Sungei Tiang	1959	4,808	3,456	1,525	—	—
	State total	—	8,154	5,756	2,456	41	893
Malacca	Kemendore	1958	4,170	2,460	2,400	600	—
	Solok Menggong	1958	1,000	600	600	5	—
	Machap	1959	1,000	720	678	71	—
	State total	—	6,170	3,780	3,678	676	—
Johore	Endau	1959	2,000	1,500	1,240	141	—
	Kong Kong	1960	3,938	3,010	1,327	—	—
	Sungei Tiram	1960	550	550	550	—	—
	Parit Hj. Idris	1960	332	250	250	—	—
	State total	—	6,820	5,310	3,367	141	—
Kelantan Trengganu Pahang	Ayer Lanas	1956	4,200	2,400	2,400	2,228	—
	Chalok	1958	4,730	2,400	1,200	—	—
	Bilut Valley	1958	6,300	4,000	3,998	—	—
	Grand total	—	36,374	23,646	17,099	3,086	893

A number of other F.L.D.A. schemes were in various stages of planning and for most of these, contracts for clearing the first phase areas had been let before the end of December. A carefully planned programme, based on R.R.I.M. advice, is followed in all F.L.D.A. schemes which are typically developed in three or four annual phases of 1,000 acres each. All F.L.D.A. schemes are planted initially with unselected seed for later budgrafting.

State Land Development Schemes

Smaller new planting schemes, typically of some 250 acres each, have been developed by State Land Development Boards and financed by State Governments. Financial assistance to these schemes is usually limited and control is very much less effective than for schemes operated by the Federal Land Development Authority. Management policy varies from state to state. Some of the larger schemes are controlled by managers but the majority are the responsibility of a District Development Committee of which the District Officer is Chairman.

A summary of the State financed block-planting schemes known to us is given in *Table 24* which shows the stage which planting had reached at 31 December 1960. Of the forty-one schemes listed, twenty-eight made their first planting during 1960. The remaining thirteen were started during 1958 or 1959. The number of schemes shown for Kedah is less than the number shown in 1959 as the very small schemes, previously initiated by the Kedah Department of Agriculture, have been omitted from the present table.

TABLE 24. NEW PLANTING WITHIN STATE LAND DEVELOPMENT SCHEMES
AT 31 DECEMBER 1960

State	Number of schemes	Total area for rubber planting	Planted with clonal seedlings	Planted with ordinary seed (for budgrafting)	Budgrafted
		Acres	Acres	Acres	Acres
Kedah	2	1,362	384	335	—
Perak	9	3,246	—	852	—
Selangor	1	252	—	252	—
N. Sembilan	7	4,921	—	3,456	2,070
Malacca	3	2,053	—	2,053	960
Johore	1	1,260	—	404	—
Kelantan	1	288	—	288	—
Trengganu	1	530	250	30	—
Pahang	16	6,320	519	4,416	—
<i>Total</i>	41	20,232	1,153	12,086	3,030

It is interesting to note that almost all schemes are planning to establish bud-grafted rubber. Clonal seedling material has been used on only two schemes, in Trengganu and on Langkawi Island, both of which are small and not easily accessible.

Advice to New Planting Schemes

Most new planting schemes have sought advice from the Service, particularly on the selection of planting material. Mr Wong Mun Yun visited 30 State schemes and one F.L.D.A. scheme, together totalling some 14,950 acres, during early stages of planning and provided detailed planting and maintenance programmes to guide the authorities responsible. Later advice has been provided by Rubber Instructors attending meetings of District Development Boards and by both Rubber Instructors and Assistant Rubber Instructors working with Scheme Managers and the settlers themselves. Collaboration with District Development Boards was not as close as it might have been and during the year only two Rubber Instructors regularly attended meetings. For some schemes all necessary information is provided from headquarters but the majority would certainly benefit from closer contact with Rubber Instructors.

Mr J. M. F. Greenwood was appointed a member of the Federal Land Development Authority on 5 September 1960. His service on this Authority and also on a number of its committees, has ensured that R.R.I.M. advice has been available for each scheme from the very earliest stage. Collaboration with the Authority, its managers and settlers within the schemes has been close indeed and has facilitated the work of both the Smallholders' Advisory Service and the development schemes. The Federal Land Development Authority is now able to follow a strict programme for development, each operation being carefully timed to take advantage of the seasons.

A Senior Officer attended one meeting each of the Pahang and Perak State Land Development Boards to take part in planning discussions and a Senior Officer attended a number of the meetings of the Jasin District Land Development Corporation responsible for the Kemendore F.L.D.A. scheme. Generally, however, more definite collaboration with both State and District Land Development Boards would be desirable. The present tendency is for the authorities to seek technical information only after difficulties arise, rather than during planning when the information would be of much greater value.

Replantings

Field staff continued to visit large numbers of individual replantings particularly to advise on the eradication of lalang, the treatment of disease and the opening of trees for tapping. Lists of holdings requiring visits in connection with these problems were provided by Replanting Officers to Rubber Instructors who arranged for the appropriate Assistant Rubber Instructor to visit each holding. This work occupied nearly half the time of all field staff, the proportion being considerably greater in the States of Malacca, Selangor and Perak where replantings were of particular importance and new planting of comparatively minor importance.

Apart from a record of visits, no data were collected on replantings as accurate information is published by the Rubber Industry (Replanting) Board, Fund(B).

Planting Material for Smallholders

Budwood available from official nurseries continued to be insufficient to supply the demand from smallholders undertaking new planting or replanting. Supplies from official nurseries were therefore supplemented by budwood obtained from thirty-eight commercial estates which had offered supplies of budwood surplus to their requirements at a price of 30 cents per yard. Nurseries on these thirty-eight estates were each inspected by a Clone Inspector of the R.R.I.M. Botanical Division and after removal of any rogues, were registered as possible sources of budwood for smallholders. Copies of the register were supplied to the Department of Agriculture, the Rubber Industry (Replanting) Board and the Federal Land Development Authority, but requests for budwood were normally passed through the State Agricultural Officer in the same way as requests for budwood from official nurseries.

The Federal Land Development Authority continued to make provision for the supply of all planting materials for its new planting schemes and while budwood is expected to be short during 1961, the shortage will be less acute than during 1960.

Budwood Used on New Plantings

A record of the quantity of budwood and the clones used on new plantings during 1960 was maintained by some Rubber Instructors. Unfortunately the records are incomplete and do not include field plantings of budded stumps or stumped buddings but they nevertheless cover the majority of budded new plantings. Details are shown in *Table 25*.

The older clones, Tjir 1 and PB 86, continue to be the most popular and together account for 70% of the budwood used on smallholding new plantings. The newer clones are, however, steadily gaining in popularity and would probably have been used to a greater extent had budwood been easily available to smallholders.

The figures show that only a small area on each holding was budded with one clone but they do not show the total acreage budded on each holding. It is interesting to note that, over nearly 6,000 acres of smallholdings, budwood was used at an average of just under 20 yards per acre. There was no restriction on the quantity of budwood provided to a single holding and the amount used suggests that efficient budders were used in each case and that the budwood supplied was in good condition.

Supply of RRIM 600 Series Clones to Smallholders

4,900 yards of RRIM 600 Series clones and the proprietary clone GT 1 were supplied to smallholders during the year. This quantity is very much greater than that supplied during 1959 and indicates an encouraging interest in the more modern planting materials. Details are shown in *Table 26*.

Sales were restricted to the clones considered most promising and the two clones RRIM 605 and 623 made up 85% of the total budwood sales. There were a number of enquiries for budwood of RRIM 628 but smallholders generally were discouraged from using this clone as, despite its very high yield, it is not considered entirely suitable for smallholders because of its poor vigour and comparatively thin bark.

TABLE 25. BUDWOOD USED ON NEW PLANTINGS 1960

State	Tjir 1			PB 86			PR 107			RRIM 513			RRIM 501			Mixed & Other Clones		
	No. of hold-ings	Acres	Yards of bud-wood	No. of hold-ings	Acres	Yards of bud-wood	No. of hold-ings	Acres	Yards of bud-wood	No. of hold-ings	Acres	Yards of bud-wood	No. of hold-ings	Acres	Yards of bud-wood	No. of hold-ings	Acres	Yards of bud-wood
Johore	477	810	17,214	190	366	8,216	140	259	5,222	53	120	2,433	63	115	2,291	108	558	9,338
Pahang	263	856	15,781	544	1,693	30,512	34	114	2,000	1	1	10	66	157	3,038	16	92	1,377
Perak	28	45	839	179	308	6,097	53	67	1,335	—	—	—	24	118	2,180	—	—	—
Malacca	9	30	610	3	3	80	6	41	90	1	1	20	1	1	20	33	70	1,421
Kedah	16	26	495	57	117	2,358	2	8	120	1	1	25	6	16	355	24	27	671
Totals	793	1,767	34,939	973	2,487	47,263	235	452	8,767	56	122	2,488	160	407	7,884	181	747	12,807
% Holdings	33.1			40.2			9.9			2.3			6.7			7.6		
% Acres		29.5			41.6			7.6			2.0			6.8			12.5	
Yards per acre			19.8			19.0			19.4			20.4			19.4			17.2

Total number of holdings — 2,398, Acreage — 5,982, Yards of budwood used — 114,148

TABLE 26. BUDWOOD SUPPLIED TO SMALLHOLDERS DURING 1960

State	RRIM 600	RRIM 603	RRIM 605	RRIM 606	RRIM 607	RRIM 614	RRIM 623	RRIM 628	GT 1	Total
Johore	38	—	258	17	41	—	488	3	4	849
Malacca	2	—	—	—	—	—	30	—	—	32
Perak	38	—	71	4	61	—	719	—	5	898
Selangor	7	—	55	7	3	—	126	1	44	243
Pahang	26	1	307	4	2	5	895	16	176	1,432
Kedah	30	—	57	15	7	—	315	—	—	424
N. Sembilan	10	—	70	4	2	—	200	—	31	317
Kelantan	4	—	22	4	58	—	478	7	35	608
Trengganu	5	—	29	—	—	—	41	—	22	97
<i>Total</i>	160	1	869	55	174	5	3,292	27	317	4,900

Manufacture

Sales of latex by smallholders were reported by Rubber Instructors at 3,883 tons (dry rubber) during the year, 1,018 tons being processed into sheet at small central factories and 3,883 tons being exported as concentrated latex or other products prepared by large commercial organisations. The total collections are notably less than during 1959, probably due to the decreased demand for liquid latex in the world market. A number of small collecting stations, which had supplied latex for concentration, closed during the year but a few continued to collect latex for processing into sheet by large organisations. The quantity of latex so processed was, however, small and the proportions of the latex made into sheet and concentrated latex remained about the same. It is always easier for producers of latex concentrate to obtain their supplies from large estates and it must be accepted that the quantity of latex required from smallholders must fluctuate with world demand. It is for this reason that sales of latex for production of a premium export product cannot be considered as a major outlet for smallholders' latex.

Three co-operative factories were in operation at the end of the year: at Kembal Batu and Ulu Kenderong (Perak); and Ulu Langat (Selangor). The Ulu Kenderong factory re-commenced operation in August 1960 after a lapse of over two years. The small co-operative factory at Sungei Buloh, Malacca, ceased operation during October 1960. The throughput of this factory had been falling for some time due to the large amount of replanting undertaken on members' holdings and the amount of latex collected was finally so small as to make the factory unecono-

mic. This is unfortunate as the Sungei Buloh factory was an excellent example of what can be done by a small group of smallholders eager to improve the quality of their product and the efficiency of processing operations. It is to be hoped that the Sungei Buloh Co-operative Society will remain in existence and will be able to commence processing once again when the production from members' holdings increases.

The large factory operated by the Rural and Industrial Development Authority at Grisek in Johore continued to process smallholders' latex throughout the year but figures of throughput are not available. This factory also purchased un-smoked sheet rubber from smallholders in the Grisek area in an attempt to spread the overheads of the factory and so to make the latex processing more economic.

At the end of the year fifteen small proprietary factories producing sheet rubber from smallholders' latex were in operation, although some operated only intermittently. Approximately thirty-one organisations continued to collect latex for supply to large commercial producers of latex concentrate, but again operation of some of these was intermittent. The average rate of latex collections by the different organisations is shown in *Table 27*.

TABLE 27. CENTRAL PROCESSING OF SMALLHOLDERS' LATEX.
AVERAGE MONTHLY RATE OF PRODUCTION 1960

State	Latex collected for sheet production			Collection for resale as latex
	Co-operative factories	Small proprietary factories	Large commercial organisations	
	pikuls d.r.c.	pikuls d.r.c.	pikuls d.r.c.	pikuls d.r.c.
Kedah	—	—	150	299
Perak	41	375	—	236
Selangor	186	385	650	220
Negri Sembilan	—	—	225	225
Johore	not available	1,347	720	2,874
<i>Total</i>	227	2,107	1,745	3,854 = 48.6%

Group Processing Centres

The efforts of field staff towards improvement of the quality of rubber produced by smallholders continued to be directed to the establishment of simple group processing centres. These centres continued to prove popular and twenty-eight were established during the year with smallholders providing the necessary capital in each case. The thirty-three centres previously established all continued in operation although the quantity of rubber handled by these decreased slightly. The position at the end of 1960 is shown in *Table 28*.

TABLE 28. GROUP PROCESSING CENTRES AT 31 DECEMBER 1960

State	Number of centres			Total with smoke-houses	Total number of users	Total monthly throughput, pikuls	Number under construction
	Established 1959	Established 1960	Total				
Kedah	3	2	5	—	53	67	3
Perak	9	5	14	2	198	292	—
Selangor	3	7	10	8	274	347	—
Negri Sembilan	1	2	3	2	41	42	1
Malacca	3	2	5	5	77	62	1
Johore	6	2	8	2	211	457	2
Kelantan	—	6	6	1	151	103	—
Trengganu	—	2	2	1	36	41	1
Pahang	8	—	8	6	126	188	—
<i>Totals</i>	33	28	61	27	1,167	1,599*	8

* Rate of production was equivalent to 1,142 tons per year.

It can be seen that the simple group processing centres, established by smallholders themselves, were benefiting over 1,100 individuals and were producing good quality sheet at the rate of over 1,100 tons per year. At the end of the year eight further group processing centres were in course of construction and the establishment of fifteen others was being discussed by different groups of smallholders.

The second improvement which can be introduced by the use of group processing centres is bulk marketing of the product to obtain a better return for the producer. Five centres introduced bulk marketing during the year, two of them by the formation of small Co-operative Marketing Societies. The three centres which commenced bulk marketing during 1959 continued bulk sales during 1960. Thus at the end of the year eight centres had taken the second step towards a fully centralised organisation.

Two group processing centres, having previously introduced bulk marketing, commenced simple bulk processing during the year. Tanks were used at one and coagulating pans at the other, but at both the latex brought in by all users was bulked after the weight and d.r.c. of each individual lot had been recorded. Paid labour was employed to process the latex at both centres. These developments, although simple, are important as they introduce a measure of management and are a definite step towards the ultimate goal of fully centralised processing of smallholders' latex at large factories.

It is notable that of the sixty-one centres in operation only twenty-seven have found it necessary to provide a smokehouse. This is because commercial smokehouses are conveniently accessible to many centres and provide the service of

smoking at a reasonable charge. It is therefore pointless for the centres to incur capital expenditure in providing a smokehouse which would, in all probability, be operated at a cost per pikul very similar to that charged by the commercial smokehouse. Where commercial smoking is not easily available every effort is made to persuade the smallholders to provide their own smokehouse so that an easily graded product may be marketed.

INFORMATION AND EDUCATION

The work of any agricultural advisory service is basically the education of the farmer. Given agricultural education, in its widest sense, the farmer not only knows the practical techniques and advances which should be applied to his crop but also appreciates the advantages to himself and to his community in applying these techniques. Considerable effort has therefore been devoted to the education of rubber smallholders by the provision of set courses of elementary instruction in all aspects of rubber growing and processing. Training courses at three levels of theoretical instruction were continued and fifty-six courses attended by 1,398 students were completed. Details are shown in *Table 29*. Fifty-two courses of different types attended by 1,397 students were in progress at the end of the year.

TABLE 29. TRAINING COURSES FOR SMALLHOLDERS 1960

Type and location	Students enrolled	Students completing courses		Examination passes and certificates awarded	
		Number	Percentage	Number	Percentage
Extension Courses (2)					
Batu Pahat (Chinese)	32	26	81.2	20	76.9
Kuala Pilah (Chinese)	32	28	87.5	18	64.3
Standard Courses (11)					
Ayer Pa'abas (Malay) (5)	92	92	100	79	85.9
Ayer Pa'abas (Chinese) (2)	37	37	100	32	86.5
R.R.I. Expt. Station (Malay) (1)	28	28	100	25	89.3
Kampongs (Malay) (3)	90	54	60	39	72.2
Practical courses (43) at kampong centres					
Malay (38)	966	719	74.4	705	no
Chinese (5)	121	78	64.5	78	examination
<i>Total</i>	1,398	1,062		996	
<i>Percentage</i>			76.0		80.4

Most effort was devoted to Practical Courses conducted by Assistant Rubber Instructors. These are suitable for most smallholders as instruction takes the form of demonstrations, followed by practical work undertaken by the students, and brief lectures provide a minimum of theory so that students may understand the reasons for the practical techniques demonstrated. Previously, certificates have been awarded to all students completing practical courses, missing less than four sessions. During October 1960, however, simple oral tests were introduced. These will be conducted at the end of each Practical Course and

certificates awarded only to those who show proof of having learnt the basic principles of practical rubber production. Tests were conducted at the end of ten Practical Courses completed during 1960 and, of the 191 students tested, 172 were awarded certificates; a pass rate of 90%.

The certificates awarded in previous years were printed in English. At the end of 1960, new certificates in romanised Malay were prepared and these will be awarded to all students completing courses after 31 December 1960. The format of the new certificates is exactly the same as the old and the standards required for the award of certificates remain unchanged.

The number of students who completed courses during 1960 was over three times the number completing courses during 1959. The proportion of students completing the courses was reduced slightly but this must be expected with the greatly increased number of students attending courses which require attendance half a day each week over a period of six or seven months. The proportion of students obtaining certificates, although very slightly higher, may be considered the same as in previous years. Results obtained at residential courses, at the R.R.I. Experiment Station and at the Smallholders' School, Ayer Pa'abas, continued to be better than those obtained in kampong centres and the overall results achieved at all courses continued to be satisfactory.

Presentation of Certificates

A number of local leaders and important officials presented certificates during parties arranged by students completing different courses. Notable among those to whom we are grateful for this interest in our work are the Chief Minister of Malacca; The Assistant Minister for Commerce and Industry; The Mentri Besar, Perak; The Deputy Mentri Besar, Kelantan; Y.A.M. Dato Undang, Rembau; Y.A.M. Dato Kelana, Sungei Ujong; Y.A.M. Dato Undang, Jelebu; The Hon'ble Tuan Haji Zainuddin; The Hon'ble Inche Mohd Sulong bin Mohamad Ali; The Hon'ble Inche Yusof Mahmood and Mr Leong Hoe Yeng. To these and to the District Officers and State Agricultural Officers who have taken an interest in different courses we are greatly indebted.

Occupations of Students Completing Courses

The object of the training courses provided by the Smallholders' Advisory Service is to instruct smallholders who will apply the knowledge gained to the improvement of their own or their parents' holdings. During December 1960, all students who had completed extension courses or standard courses during 1959 and 1960 were contacted by field staff, when it was found that 72.4% were working either full time or part time on rubber smallholdings. This is almost exactly the proportion recorded in previous years and it is pleasing to know that so many students continue to work on smallholdings, not for a short time only but over a long period. Details are shown in *Table 30*.

Of those not employed on rubber smallholdings, nine were working with the Rubber Industry (Replanting) Board, four with the Federal Land Development Authority, two with the Department of Agriculture and one in the Smallholders' Advisory Service. 59 were continuing as students, 13 working as teachers, 35 had no permanent employment and the remaining 23 were following gainful occupations where their knowledge of rubber was unlikely to be of value. Many of those

Smallholders' Advisory Service: Information and Education

TABLE 30. OCCUPATIONS OF STUDENTS COMPLETING COURSES 1959 AND 1960,
AS AT 31 DECEMBER 1960

Type of course	Employed in rubber work			Not working on small-holdings	Not contacted	Total
	Full Time	Part Time	Percentage			
Extension courses (6)	57	18	56.4	58	2	135
Standard courses						
Ayer Pa'abas (14)	154	20	78.0	49	10	233
RRI Expt Station (2)	31	14	81.8	10	1	56
Kampong centres (9)	103	22	80.6	30	—	155
<i>Total</i>	345	74	419	147	13	579
<i>Percentage</i>	59.6	12.8	72.4	25.4	2.2	100

continuing as students had attended extension courses and were boys whose families owned sizeable rubber holdings. Their knowledge is therefore likely to be applied at some future date. The technical knowledge of past students working for official organisations is also usefully applied and of direct benefit to the smallholder rubber industry. The training of only 58 students, that is 10% of all students trained, must be considered as wasted. The remaining 90% are all obtaining a real benefit from the courses which they attended.

Students who had attended practical courses were not contacted, partly because of the large number involved but more particularly because these students were all working smallholders at the time they attended courses. It can be assumed, therefore, that they are continuing to work their holdings and to apply the knowledge gained at their course.

Training Courses for Other Organisations

Fifteen students from the Department of Agriculture, Sarawak and four from the Department of Agriculture, Brunei, attended courses at Ayer Pa'abas. They attended in groups of three or four at each course and followed the normal syllabus provided for smallholders.

At courses provided for the training of prospective Assistant Rubber Instructors three students from the Department of Agriculture, Sarawak; eleven from the Federal Land Development Authority; three from the Rubber Industry (Replanting) Board; four from the Rural and Industrial Development Authority, and four from the Ministry of Education were accepted. Three private students also attended these courses making a total of twenty-eight students not training as prospective recruits for the Smallholders' Advisory Service. It is possible to provide only two courses for prospective Assistant Rubber Instructors each year and in view of the increased recruitment of Assistant Rubber Instructors which is necessary, the number of students accepted from other organisations must in future be reduced.

Courses provided by the Department of Agriculture at Rural Training Centres continued to include instruction on rubber growing and processing provided by Rubber Instructors or Assistant Rubber Instructors. The amount of instruction provided at these courses varied from centre to centre but was normally sufficient only to cover specific aspects in the barest outline.

A special practical course was provided at the Sungei Besi Boys' Home. This followed the standard syllabus and made use of rubber plantings in the Home grounds for practical work. The course was initiated by 'Che Mohd Johar who was later assisted by an Assistant Rubber Instructor who will repeat the course if required. Certificates were presented to successful students by the Minister for Health and Social Welfare.

Visits by Students to the Institute and Experiment Station

As a finale to an instruction course, groups of students frequently arranged to visit the R.R.I.M. Experiment Station and the Institute in Kuala Lumpur. These visits were undertaken at the expense of the students themselves and normally comprised a morning spent at the R.R.I.M. Experiment Station and part of the afternoon at the Institute. Numbers of smallholders who had not attended the course frequently accompanied the students on these visits. Twenty-three groups of students and smallholders, totalling 709 persons, made such visits during the year.

Mobile Demonstration and Film Units

Two new mobile units were put into service during August so that there was a total of three units able to give either demonstrations on rubber processing or film shows and one unit equipped to give film shows only. This latter unit was replaced during December by a new vehicle equipped to provide both demonstrations and film shows.

Demonstrations and film shows were conducted during the year as shown in Table 31. It is estimated that over 76,000 smallholders attended the film shows and nearly 3,000 the demonstrations of sheet making. The distribution of the shows and demonstrations reflects the distribution of field staff and more attention will be given to the East Coast States in future.

TABLE 31. USE OF MOBILE UNITS 1960

S t a t e	Processing demonstrations	Film shows
Kedah/Perlis	10	37
Perak	10	26
Selangor	10	53
Negri Sembilan	20	29
Malacca	18	20
Johore	9	46
Kelantan	7	20
Trengganu	1	4
Pahang	9	18
<i>Total</i>	94	253

The demonstration units were used also at agricultural shows and in conjunction with a special campaign to popularise group processing centres in Negri Sembilan. This campaign was organised by Mr Lim Hong Hai between 12 and 24 September, during which period all field staff in Negri Sembilan devoted their full time to lectures, film shows and demonstrations on rubber sheet making and discussions on group processing centres. Twenty-six processing demonstrations were conducted and seventy-one lectures, illustrated by cine films or coloured slides, provided.

As much publicity as possible was given to this campaign and assistance was given by the Mentri Besar, District Officers, the Department of Information, the State Rural Development Officer and the State Agricultural Officer.

As a direct result of the campaign one group processing centre was established by the end of the year and plans for group processing centres were being discussed in a number of other kampongs. The impact of the campaign is being followed up by regular advisory work and results are promising.

Agricultural Shows and Rubber Sheet Making Competitions

The Service participated in fifteen agricultural shows occupying a total of twenty-one days in Johore, Perak, Selangor, Pahang, Kedah and Trengganu. At six of these shows sheet making competitions were organised by the Service while trophies and cash prizes were awarded by commercial firms and the show committees. Three hundred and seventeen smallholders, of whom fifty-five were women, competed during thirteen days for a total of \$1,408 in prize money.

While educational exhibits were provided at all agricultural shows it was considered that the organisation and judging of sheet making competitions was probably the most valuable contribution which the Smallholders' Advisory Service could make. These competitions were popular among smallholders and at the same time attracted large groups of spectators and stimulated questions on the processing of sheet. The competitions were judged on the basis of the sheet making method recommended by the Service and the possibility of competing in a sheet making competition provides some added incentive to smallholders to learn and practise this method.

Publications

A series of five boldly coloured posters, with captions in Rumi and under the slogan 'Menuris ikut aturan, Hasil akan berkekalan', was issued, not for general display but to serve as illustrations during lectures and a lasting reminder of the points discussed.

Revised editions of 'Lalang Control with Dalapon' and 'Budgrafting' were printed and distributed. Revised editions of 'Better Rubber and More Profit' and 'Replanting on Smallholdings' were with the printer at the end of the year.

Publications in the appropriate language were provided to each student attending a training course and others were distributed by field staff or issued direct from headquarters to smallholders enquiring for them. During the year a total of nearly 15,000 booklets and leaflets was issued in these ways as part of the effort to educate smallholders.

Regular contributions were made to the R.I.(R)B. newspaper 'Arah Kema'muran'. Nine technical articles of topical interest appeared and the text of our booklet 'Control of Root Disease in Young Rubber' was modified for serial publication in two issues. The R.I.(R)B. newspaper is distributed without charge to a very large number of kampong dwellers and is a valuable medium of technical publicity.

R.I.(R)B. Publicity Campaign

The annual publicity campaign, arranged by the Rubber Industry (Replanting) Board, Fund B to encourage smallholders to replant and to take full advantage of the assistance available, again took the form of a series of discussion meetings in the kampongs. A Rubber Instructor or Assistant Rubber Instructor attended each gathering to provide information on the Service and to answer technical questions raised by smallholders engaged in replanting.

J. M. F. GREENWOOD
Smallholders Advisory Officer

Estates Advisory Service Division

The year has been one primarily of expanding and training staff so that by the end of the period under review there remained only one vacancy unfilled. Mr L. R. Davidson, Head, Estates Advisory Service, left on retirement on 8 October and Mr F. W. Hutchison was transferred from the Pathological Division and appointed as his successor from that date.

Mr J. H. Chapman joined the Service as Advisory Officer on 17 February. On 4 July, Mr N. S. Bharathi, a Tamil-speaking officer, took up appointment as Assistant Advisory Officer. Mr Lim Bock Tong, a second Chinese-speaking officer, reported for duty as Assistant Advisory Officer on 17 October.

Expansion of the Service

In 1959 expansion of the service was severely handicapped through lack of staff and as a consequence Soils Division was the only Division whose routine advisory work was completely taken over by the Estates Advisory Service in that year. In 1960 the continued staffing improvement has enabled the routine advisory work of the Pathological and Botanical Divisions to be included gradually. This increase in the field of advisory subjects has been well met with by the existing staff but no general effort has been made to extend our service to estates which do not seek R.R.I.M. advice. This will follow when the new staff has completed training. The one exception is that there has been a slight extension of the number of contacts with Chinese-owned estates where survey work started last year. It is gratifying to note that such visits frequently lead to requests from neighbouring estates for advisory visits. Towards the end of the year we were able to make a sample survey of Indian-owned estates on a very limited scale and this work will be extended in 1961.

Estate visits play a most important part in the advisory service and in improving conditions and production. Our experience shows that many of the smaller proprietary estates are in need of general advice on all aspects of the subject and it is within this group that the greatest improvement is possible. In many cases these estates have remained uninformed through lack of information on the functions of the R.R.I.M. rather than through reluctance to receive advice. Our main aim has been to contact this group, and it is our policy to extend visits to these estates as much as possible. On the other hand, larger estates seek advice more specifically on single problems and, having had more contact in the past with the Institute, are not hesitant in asking for visits.

Visitors

One hundred and thirty-six visitors, mostly proprietary estate owners, visited the Institute and arrangements were made for twenty-two parties of planters, totalling 103, to visit the Experiment Station.

Correspondence

The take-over of advisory work from the Pathological and Botanical Divisions in the middle of the year is reflected in the correspondence which shows an appreciable upward trend (50%) in letters despatched over the previous year. The

numbers of letters received and despatched in 1960 were 1,358 and 1,687, respectively. With attention being focused on the smaller estates, it is interesting to note that there was a relatively large number of enquiries on the more basic subjects, such as planting materials, planting operations, tapping and manuring.

Advisory tours have been increased during the year and it has been possible to make some follow-up visits. This aspect of visiting is most important in encouraging and maintaining interest and in enabling Advisory Officers to see the results of their advice and to pass back information to research officers.

A tour was arranged to Kelantan and Trengganu States which have been neglected in the past. This establishment of contact with estate owners on the east coast resulted in a party of planters paying a visit to the Experiment Station and further requests for visits are forthcoming.

The total number of visits to estates during the year was 318.

ADVISORY

Planting Operations and Maintenance

There has been a general increase in requests for advice on subjects such as suitability of land for planting with rubber, or replanting especially old abandoned seedling material. It is unfortunate that our advice is often sought after an area has been replanted when earlier guidance would have proved far more beneficial. Where we have had the opportunity, we have persuaded estates to take advantage of the Government Replanting Scheme, to replace their low yielding areas up to the 21% allowance.

Manuring

In general, manuring standards are fairly well understood by estates and the readily available advice from commercial organisations on this subject may be the reason why requests under this heading are usually to confirm if an estate programme is adequate. There is still however a general inability to recognise deficiency symptoms. Manganese deficiency symptoms have been fairly widely noted.

Cover Plants and Weed Control

Much advisory work is still needed on the establishment of cover crops. On many of the smaller estates they are not only poorly sown but also badly maintained and grasses take over in a very short time. Under these circumstances it is not surprising that many estates doubt the value of sowing covers. Death of covers both through *Rhizoctonia* and eelworm attack have been reported, but in general poor cover growth has been the result of poor management.

The larger estates who have had access to sodium arsenite are now seeking advice on alternative herbicides in view of forthcoming ban on the use of sodium arsenite. The smaller estates are generally in need of information on the identification of weeds and on the specific uses of the more selective weed-killers.

Planting Material

On proprietary estates, advisory work on planting material is concerned not so much with recommending high yielding clones, as with discouraging the wholesale use of high yielding experimental clones and clones intended for small-scale planting. There continues to be a demand from the larger estates for advice on secondary characteristics of the newer clones to help them in their selection for field planting.

Tapping and Stimulation

Although this is a field on which much advice could be given, requests have not been numerous. There is still much reluctance in many quarters to consider more intensive tapping systems and stimulation other than as a prelude to slaughter tapping. Where advice has been requested, it has usually been on the subject of alteration of technique of application or change of stimulant. In many of the older areas on small estates, limitations on tapping and stimulation are provided by lack of bark.

Diseases, Pests and Injuries

Root disease is still the major problem but except on the small estate, it is not a problem of identification, but of understanding the principles behind the recommended method of treatment. Wherever root disease has been encountered efforts have been made to demonstrate correct techniques of control.

Pink disease, sodium arsenite injury and lightning damage have made up the bulk of other enquiries under this heading.

F. W. HUTCHISON
Head of Estates Advisory Service

Publications and Information

Two Assistant Publications Officers were appointed in the second half of the year: Che Abu Bakar (Malay language) and Mr Chen Yong Sien (Chinese language). Their main task will be the publication of Malay and Chinese versions of *Planters' Bulletin*.

PUBLICATIONS

It will be noted that articles contributed to various journals by individual R.R.I.M. authors and Divisions are no longer presented in the reports of the Divisions but are given in a separate list, 'Publications of the R.R.I.M. 1960', which also contains the papers presented by R.R.I.M. staff at the Natural Rubber Research Conference, Kuala Lumpur, 26 September – 1 October 1960.

Annual Report. The *Annual Report 1959* was published in September.

Journal. Parts II, III and IV of Volume 16 were issued during the year, Part IV concluding the volume. An Index for Volume 15 was published and work continued on the preparation of indexes for previous issues.

Planters' Bulletin. Normal publication continued and the cumulative subject index for 1952–9 was prepared for publication in March 1961.

Planters' Bulletin (Malay and Chinese Languages). The Assistant Publications Officers (Malay and Chinese Languages) began work on the preparation of standard vocabularies for these languages and later on the translation of articles for the Chinese and Malay versions of *Planters' Bulletin*, to be issued quarterly, beginning in March 1961.

It was decided, in view of the large potential demand for these publications, to increase the initial issue of these publications beyond the figures originally planned. The first issue of these publications will be: Malay (Rumi) 6,000; Malay (Jawi) 10,000; Chinese 9,000.

Brochure. An illustrated brochure describing the history and functions of the Institute was published in July. It proved immediately popular and later in the year an order for 3,000 copies was received from the Natural Rubber Bureau in the United States of America.

Miscellaneous publications. Various advisory leaflets were issued or reissued.

The Natural Rubber Research Conference. The Publications Officer was appointed Chairman of the Editorial Sub-Committee for the Conference which began on September 26th. Work began on the editing of the 80 papers in July and preprints of the papers were made for use during the Conference. Twenty-nine papers were presented by R.R.I.M. authors. Subsequently the papers were re-edited, and collated for the publication of the *Proceedings of the Natural Rubber Research Conference* as a bound volume early in 1961.

Contributions to non-R.R.I.M. publications. Eight papers were contributed to outside journals during the year.

Publications and Information

LIBRARY

Orders for new library shelving, equipment and furniture were placed at the beginning of the year. Although delivery had been promised for the beginning of August, a series of postponements for various reasons delayed completion of the work of reconstruction and it was still not complete by the end of the year.

From 1 September the library building was vacated, following the decision to use it as a lecture hall for the Natural Rubber Research Conference. The journal stock, reference works and post-1940 books were all transferred to an R.R.I. bungalow, No. 2 Ridley Close. The pamphlets and pre-1940 books were stored in the Institute.

Journal circulation lists were revised in preparation for the new circulation scheme.

Considerable further progress was made during the year with the cataloguing of the stock of books.

A photocopying service was introduced in April and by the end of the year more than 3,500 sheets had been produced. A microfilm reader was ordered.

W. J. BAULKWILL
Publications Officer

Publications of the R.R.I.M. 1960

(In addition to 1960 publications, this list contains contributions made by R.R.I.M. staff to the Natural Rubber Research Conference, Kuala Lumpur 1960, the *Proceedings* of which are to be published in 1961)

SOILS DIVISION

Scientific journals. Four papers were contributed to recognised scientific journals during the year:

- BOLTON, J. The response of *Hevea* to fertilisers on a sandy latosol. *J. Rubb. Res. Inst. Malaya* 1960, **16**, p.178.
- MIDDLETON, K. R. A comparison of rock phosphate and superphosphate as sources of phosphorus for seedling rubber. *J. Rubb. Res. Inst. Malaya* 1960, **16**, p.139.
- MIDDLETON, K. R. A new Nessler reagent and its use in the direct nesslerization of Kjeldahl digests. *J. appl. Chem.* 1960, **10**, p.281.
- WATSON, G. A. Interactions of lime and molybdate in the nutrition of *Centrosema pubescens* and *Pueraria phaseoloides*. *J. Rubb. Res. Inst. Malaya* 1960, **16**, p.126.

Other journals. There were four contributions to *Planters' Bulletin* during 1960:

The nitrogen content of leguminous creeping covers	...	<i>Planters' Bulletin</i>	47
Soil reaction and rubber cultivation	...	..	50
An experiment with magnesium limestone	...	..	50
Recent developments in the diagnosis of fertiliser requirements	...	..	51

Conference papers. Four papers were contributed to the Natural Rubber Research Conference, Kuala Lumpur 1960:

- BOLTON, J. The effect of fertilisers on pH and the exchangeable cations of some Malayan soils
- MIDDLETON, K. R. Inconsistencies on the response of *Hevea brasiliensis* to phosphatic fertilisers in field trials and in pot experiments with soil
- SHORROCKS, V. M. Some effects of fertiliser applications on the nutrient composition of leaves and latex of *Hevea brasiliensis*
- WATSON, G. A. Cover plants and the soil nutrient cycle in *Hevea* cultivation

BOTANICAL DIVISION

Scientific journals. Four articles were contributed during the year:

- BOATMAN, S. G. Detection and estimation of growth substances in *Hevea* latex. *J. Rubb. Res. Inst. Malaya* 1960, **16**, p.166.

- TINLEY, G. H. (co-author GARNER, R. J.) Developments in the propagation of clones of *Hevea brasiliensis* by cuttings. *Nature, Lond.* 1960, **186**, No. 4722, p.407.
- WYCHERLEY, P. R. Seed germination of some tropical legumes. *J. Rubb. Res. Inst. Malaya* 1960, **16**, p.99.
- WYCHERLEY, P. R. Vegetation of rubber plantations. *J. Rubb. Res. Inst. Malaya* 1960, **16**, p.87.

Other journals. There were nine contributions to *Planters' Bulletin*:

Amendments to planting recommendations 1959 – 60	...	<i>Planters' Bulletin</i>	46
<i>Clitoria rubiginosa</i>	...	„	46
RRIM 600 series clones	...	„	46
RRIM 600 series clones in estate trials	...	„	48
Planting materials used in Malaya 1955 – 8	...	„	49
A crown budding experiment	...	„	49
Seed treatment and sowing methods for cover crops	...	„	50
Stimulation of yield: A comparison of proprietary yield stimulants	...	„	51
Two <i>Phaseolus</i> species of interest	...	„	51

The following article was also published during the year:

- BOATMAN, S. G. Yield stimulation in *Hevea brasiliensis*. *The Planter* 1960, **36**, p.185.

Conference papers. Six papers were contributed to the Natural Rubber Research Conference, Kuala Lumpur 1960:

- BOATMAN, S. G. Chromatography and bioassay of plant growth substances in *Hevea latex*
- CHANDAPILLA, M. M. Vegetation sampling in cover plant trials
- DE JONGE, P. Intensive tapping of mature rubber
- ROSS, J. M. Observations on the 1959 hand pollination programme at the Rubber Research Institute of Malaya
- TEMPLETON, J. K. Some aspects of the growth of *Hevea* buddings
- TINLEY, G. H. Vegetative propagation of clones of *Hevea brasiliensis* by cuttings

PATHOLOGICAL DIVISION

Scientific journals. The following paper was published during the year:

- JOHN, K. P. Loss of viability of three root parasites in infected root sections buried in soil. *J. Rubb. Res. Inst. Malaya* 1960, **16**, p.173.

Other journals. Three articles were contributed to *Planters' Bulletin*:

Secondary leaf fall and South American leaf blight	...	<i>Planters' Bulletin</i>	46
Tree and stump poisoning	...	„	47
Trapping cockchafer beetles	...	„	51

Conference papers. Two papers were contributed to the Sixth Commonwealth Mycological Conference, London, 1960:

FOX, R. A. White root disease of *Hevea brasiliensis*: recent developments in control techniques

FOX, R. A. White root disease of *Hevea brasiliensis*: the role of fungicides in control techniques

Four papers were contributed to the Natural Rubber Research Conference, Kuala Lumpur, 1960:

FOX, R. A. White root disease of *Hevea brasiliensis*: the identity of the pathogen

HILTON, R. N. Sporulation of *Fomes lignosus*, *Fomes noxius* and *Ganoderma pseudoferreum*

HUTCHISON, F. W. Factors affecting root disease incidence and control in replanting

NEWSAM, A., JOHN, K. P. and RAO, B. S. Decay of rubber wood

CHEMICAL DIVISION

Scientific journals. Eight papers were contributed:

GALE, R. S. An apparatus for the study of the drying rates of sheet rubber
J. Rubb. Res. Inst. Malaya 1960, **16**, p.119.

HSIA, R. C. H. (co-author DALZIEL, J. A. W.). The determination of traces of copper in rubber latex ash by neutron activation analysis. *Proceedings of Symposium on Advances in the Chemical Analysis of Soil, Fertilisers and Plants (1960), London.* Abstract and discussions published in *Chem. and Ind.* 1960, No. 33, p.1043.

MOIR, G. F. J. and TATA, S. J. The proteins of *Hevea brasiliensis* latex. Part 3. The soluble proteins of 'bottom fraction'. *J. Rubb. Res. Inst. Malaya* 1960, **16**, p.155.

SEKHAR, B. C. Degradation and crosslinking of polyisoprene in *Hevea* latex during processing and storage. *International Symposium on Macromolecular Chemistry, Moscow* 1960. Published in *J. Polymer Sci.* 1960, **43**, p.133.

SEKHAR, B. C. The soap titration method of estimating the particle size of *Hevea* latex. *J. Rubb. Res. Inst. Malaya* 1960, **16**, p.93.

SETHU, ST. Ion-exchange properties of nitrogenous-coated cellophane membranes. *J. appl. Polym. Sci.* 1960, **3**, p.368.

SOUTHORN, W. A. The torsionmeter—an instrument for the study of gels considered as elastic solids. *J. sci. Instrum.* 1960, **37**, p.292.

SOUTHORN, W. A. Complex particles in *Hevea* latex. *Nature, London* 1960, **188**, No. 4745, p.165.

Other journals. Eight articles were published in *Planters' Bulletin* :

Low ammonia latices: the use of boric acid	<i>Planters' Bulletin</i>	46
Production of PA 80	"	47
SP rubber: progress in 1959	"	47
Sheet production. Rapid drying needs good machining	"	47
Influence of field latex on latex concentrate quality ...	"	48
Research developments at the R.R.I.M.	"	48
Removal of pigments from latex for pale crepe production	"	49
Editorial. Technical service to the Malayan rubber manufacturers	"	49

Conference papers. Fifteen papers were presented at the Natural Rubber Research Conference, Kuala Lumpur, 1960:

- ANGOVE, S. N. and DRAKE, G. W. The specific gravity of natural rubber latex
- DRAKE, G. W. Production of SP rubbers
- GALE, R. S. Bubble and blister formation in sheet rubber
- KARUNAKARAN, A. J., MOIR, G. F. J. and TATA, S. J. The proteins of *Hevea* latex: Ion-exchange chromatography and starch gel electrophoresis
- MOLESWORTH, T. V. The treatment of aqueous effluent from rubber production using a trickling filter
- MORRIS, J. E. and NIELSEN, P. S. Properties of low grade rubbers (Estate Brown Crepe)
- PEPPER, ROSEMARY. Astell roll-tube technique and its application to the testing of latex samples
- PEPPER, ROSEMARY. Low temperature inhibition of bacterial growth and its application to testing of latex samples
- SEKHAR, B. C. Inhibition of hardening in clonal rubbers
- SEKHAR, B. C. Methyl methacrylate graft rubbers of predetermined molecular characteristics
- SEKHAR, B. C. and NIELSEN, P. S. New types of Superior Processing rubbers
- SOUTHORN, W. A. Microscopy of *Hevea* latex
- TAYSUM, D. H. Bacterial counts and their relation to volatile fatty acid content, KOH number and mechanical stability
- TAYSUM, D. H. The establishment of a bacterial population of latex vessels during normal tapping
- TAYSUM, D. H. Yield increases by the treatment of *Hevea brasiliensis* with antibiotics.

Miscellaneous publications. Technically Classified Natural Rubber. *Technical Bulletin* No. 39 (a cyclostyled serial publication issued annually for restricted distribution) was published. Early in the year *A Nomograph for the Drying of Sheet Rubber*, by R. S. Gale, was issued for the use of estates.

The R.R.I.M. Experiment Station

Mr J. F. McEwen was appointed assistant manager on 1 March.

Training courses. The following courses were held on the station:

Four courses of five days for forty-eight Senior Estate Conductors.

Two courses each of about two and a half months duration for ninety-two prospective Junior Rubber Instructors.

One course of ten days for forty-seven students from the College of Agriculture, Serdang.

One course of four weeks for twenty-eight Kampong Youths.

Visitors. There were 1580 visitors to the station during the year, including many large parties of smallholders and students from smallholders training schools.

Health. Throughout the year the health of the labour force and staff resident on the station was good. There were fifty-eight births and six deaths. One-hundred-and-two cases were admitted to hospital and 1515 minor cases were treated locally. There were no cases of malaria.

Acreage. Details of the acreage statement at 31 December were:

	<i>Acres</i>
Mature rubber in tapping	1,412.25
Mature rubber resting (Field 54)	36.50
Immature rubber	1,248.00
Nurseries	59.00
Building site and roads	106.25
Reserve land, swamp etc.	117.00
	2,979.00

Rainfall. Total rainfall for the year at 86.46 in. was exceptionally low and is in contrast to 124.17 in. in 1959. Rain fell on 180 days.

<i>Month</i>	<i>Rainfall, in.</i>	<i>Period, days</i>	<i>Month</i>	<i>Rainfall, in.</i>	<i>Period, days</i>
January	5.32	16	July	6.27	14
February	5.43	13	August	3.92	14
March	9.32	13	September	8.07	11
April	9.63	17	October	12.44	17
May	2.96	12	November	13.41	21
June	1.64	10	December	8.05	22

REPLANTING

One hundred and twenty-three acres of old rubber were cleared for replanting. The main areas were in Field 14, where 45.75 acres will be used for root disease experiments, in Field 20 where 16.25 acres will be used as an experiment on

methods of management of legume and non-leguminous covers, in Field 21 where 23.75 acres will be mainly utilised for fertiliser trials, and in Fields 23A and 42W where 19.25 acres are being prepared for root disease experiments.

IMMATURE AREAS

Budgrafting

Field 19 (West) (35 acres). This field was budded with clone PB 5/51.

Field 64A (47 acres). A large scale clone trial, comprising nine RRIM 700 series clones, seven other new R.R.I. clones, and six proprietary clones, with clones PB 86, RRIM 513 and 605 as controls, was budded in this field with five replicated plots of one-third of an acre for each clone. In addition sixteen other clones were selected and budded in single plots for observation.

Field 64B (60 acres). A small scale clone trial of simple lattice design of 870 new clones was budded in this field, using control plots of clone RRIM 605.

Field 64D ($3\frac{1}{2}$ acres). This small area was planted with cuttings and budded stumps of clones PB 86, GT 1 and FX 652.

Field 64E ($28\frac{1}{2}$ acres), comprising the boundaries and discard sections around the above experiments was budded with clone RRIM 519.

Field 65. The following clones were budded in the various sections:

A and D	15 acres clone RRIM 513
B	18 „ „ „ 605
C	16 „ „ „ 623
E (discard)	21 „ same clone as adjacent experimental area.

In all cases cutting back remained to be done at the end of the year.

Manuring

Fertilisers were applied to 954.25 acres of immature rubber (excluding manuring experiments), at standard rates and using appropriate single fertilisers and mixtures.

Leguminous covers received fertilisers, chiefly rock phosphate, over 416.25 acres.

Thinning Out

Field 58B. The stand was reduced to 150 trees per acre (5 trees per plot).

Field 60D. The stand was reduced to 164 trees per acre (82 trees per plot).

Supplying

Vacancies in Fields 17, 19, 64 and 65 were supplied with budded stumps of the appropriate clones.

Pests and Diseases

Root disease. All immature areas over one year old remained on quarterly foliage inspection for diagnosis of root disease. A summary of incidence is given in Table 32.

TABLE 32. NUMBER OF CASES OF ROOT DISEASE IN IMMATURE AREAS

Type of area	New clearing		Replanting		Total no. of cases
Area inspected	646 acres		222½ acres		
Action taken	Treated	Removed	Treated	Removed	
<i>Fomes lignosus</i>	244	268	275	313	1,100
<i>Ganoderma pseudosferreum</i>	53	111	11	62	237
<i>Fomes noxius</i>	36	66	5	23	130
<i>Ustulina zonata</i>	11	14	4	6	35
<i>Total</i>	344	459	295	404	1,502

Pink disease. Five hundred and seventeen acres of young rubber were under regular inspection. A total of 2,462 cases were treated (including recurrent cases).

Termites. Five hundred and sixty-nine acres of young rubber, including Fields 19, 58, 60, 61, 64 and part of 65 were given a prophylactic application of Aldrex 1:400.

Caterpillars. In Fields 64 and 65 there was a heavy attack by caterpillars (*Tiracola plagiata*) on the natural covers, especially the *Trema* species, but a 1% solution of Endrex sprayed from low volume mechanical pumps brought the pest under control.

Storm damage. Two-hundred and fifty-four cases were pruned and fifty-one fallen trees cleared.

General Maintenance of Immature Areas

Young rubber was strip-weeded manually up to the fifth calendar year and selective weeding in the inter-rows was carried out till the end of the fourth year. Older areas came under regular rounds of strip spraying with sodium arsenite or sodium chlorate. Natural covers were slashed to a height of three feet periodically.

MATURE AREA

The system of maintenance and upkeep of mature rubber remained unchanged.

Manuring

Applications of fertilisers, mainly mixture C2 and mixture Magnesium Y, were made on 736.25 acres.

Pests and Diseases

Root disease. 575.5 acres of young mature rubber were inspected. Seventy-five cases were treated and seventy-eight trees were removed.

Pink disease. Five-hundred-and-one cases were treated.

Termites. Five-hundred-and-sixty-six cases were treated.

Storm damage. One-thousand-six-hundred-and-sixty cases were pruned. Nine-hundred-and-eighty-four fallen trees were cleared.

Tapping

New areas of rubber amounting to 178.75 acres, were brought into tapping during the year, and intensive tapping (200%) was carried out over 58.25 acres. In addition, all fields cleared for replanting were tapped at 200% (or more) intensity prior to felling.

Crop

The total crops at 1,341,481 lb was about 30,000 lb less than in 1959, and the yield per acre decreased by about 40 lb to 968 lb per acre.

Normal tapping	...	...	...	...	...	...	...	303 days
Late tapping	...	...	...	...	...	...	...	32 "
Rain interfered	...	...	...	...	...	...	...	8 "
No tapping (Rain)	...	...	...	...	...	...	...	12 "
No tapping (Holiday)	...	...	...	...	...	...	...	11 "

Manufacture

The following grades of rubber were manufactured:

RSS	...	...	...	...	...	...	...	388,706 lb
SP RSS	...	...	...	...	...	...	...	72,725 "
Latex concentrate d.r.c.	...	...	...	...	...	...	...	247,533 "
SP brown crepe	...	...	...	...	...	...	...	64,007 "
Lower grade crepes	...	...	...	...	...	...	...	324,364 "
PA 80	...	...	...	...	...	...	...	187,664 "
Skim crepe	...	...	...	...	...	...	...	23,730 "

Unmanufactured

Smoked scrap	...	...	...	...	...	...	...	500 lb
Latex d.r.c. (for experimental use)	...	...	...	...	...	...	...	10,545 "
Cup samples	...	...	...	...	...	...	...	21,707 "

1,341,481 lb

Seed Gardens and Multiplication Nurseries

The seedfall during the main season August to October was poor and finished unusually early. The covers in the seed gardens were sprayed with sodium arsenite just prior to the seedfall.

A total of 329,700 seeds were collected and despatched to the Department of Agriculture.

11,032 yards of budwood of various clones were cut and despatched to estates and smallholdings.

Five acres of additional multiplication nursery were budded with selected clones during the year including one acre of selected material for the Department of Agriculture.

EXPERIMENTAL

Further details of work under this heading are contained in the reports of the Divisions concerned. The Experiment Station Staff were responsible for the yield recordings (mainly by cup-coagulation), for the various growth measurements taken in the different experiments with manures, clones and cover plants, and also for the experimental treatments with fertilisers, herbicides, and yield stimulants carried out in various trials.

BUILDING, PLANT AND MACHINERY

The Type B smoke house, which was under construction at the end of 1959, was completed. One half of this building has been in regular use whilst the second half, which incorporates various insulating materials and an entirely new design of furnace, was only completed in December.

Five units of junior staff quarters and one senior staff bungalow were repainted and reconditioned. All labour lines were colour washed and maintenance repairs were carried out throughout.

Eight units of latrines with septic tank sewage were provided for the trainees quarters.

Machinery

A new De Laval 410 Centrifuge was received in December and is being installed in the factory.

The carpenter's workshop was equipped with an electric band saw and a planing machine.

Electricity and Water Supply

Generators in the power house were maintained regularly. No electrical or water supply difficulties were experienced.

Roads

Sixty-eight chains of roadway in the main building site were resurfaced.

LABOUR

There was an ample supply of labour. Wage rates varied in accordance with price zones announced monthly by M.P.I.E.A.

The labour strength on 31 December was:

<i>On check roll</i>					<i>Men</i>	<i>Women</i>	<i>Children</i>	<i>Total</i>
Indians	...	...	...	...	219	185	28	432
Malays	...	...	...	...	16	2	—	18
Chinese	...	...	...	...	1	2	—	3
Total on check roll					236	189	28	453
<i>On contract</i>								
Malays	...	...	...	...	16	4	—	20
Chinese	...	...	...	...	—	2	—	2
Total workers					252	195	28	475
Dependants (Indians)					14	25	441	480

In addition about 50 field labourers from the neighbouring new villages were employed regularly through contractors.

R. F. HARLEY
Manager
R.R.I.M. Experiment Station

SENIOR STAFF*

ADMINISTRATION

- C. E. T. Mann, M.Sc., F.I.R.I., *Director*. (15 June 1927). Retired January 1960
 C. G. Akhurst, B.Sc., A.R.C.S., A.I.C.T.A., *Deputy Director*. (7 October 1930),
Acting Director. (February 1960)
 J. C. Reeves, F.C.C.S., *Secretary*. (11 September 1950)
 H. F. Logan, *Assistant Secretary*. (12 January 1959)
 J. A. Faulkner, *Maintenance Engineer*. (1 November 1955)

PUBLICATIONS AND INFORMATION SECTION

- W. J. Baulkwill, B.A., N.D.A., *Publications and Information Officer*. (6 January 1959)
 A. G. Parker, A.L.A., A.I.L., *Librarian*. (20 April 1959) Seconded from N.R.P.R.A.

STATISTICS DIVISION

- D. R. Westgarth, M.Sc., *Head of Division*. (19 November 1959)
 A. Fong Chu Chai, Dip. Arts, B.Sc. *Statistician*. (8 July 1949)
 G. Chidambara Iyer, M.Sc., *Assistant Statistician*. (20 August 1955)

EXPERIMENT STATION

- R. F. Harley, M.C., F.I.S.P., *Manager*. (27 August 1937)
 J. D. Macritchie, B.Sc. (Agri.), *Assistant Manager*. (15 December 1954)
 C. Y. Ross, *Assistant Manager*. (23 October 1959)
 J. F. McEwen, B.Sc. (For.), *Assistant Manager*. (1 March 1960)
 G. A. Gilbertson, *Resident Engineer*. (18 May 1959)

SOILS DIVISION

- G. Owen, M.Sc., F.I.S.P., *Head of Division*. (5 January 1939) Retired 23 May 1960
 G. A. Watson, M.Sc., Ph.D., A.R.C.S., D.I.C., A.R.I.C., *Head of Division*. (8 November 1955)
 V. M. Shorrocks, M.A., D.Phil., M.I. Biol., *Plant Physiologist*. (28 August 1957)
 K. R. Middleton, M.Sc., A.R.I.C., *Soils Chemist*. (16 October 1958)
 J. Bolton, B.Sc., A.R.I.C., *Soils Chemist*. (24 October 1958)
 M. M. Guha, B.Sc., Assoc. I.A.R.I., *Assistant Soils Chemist*. (20 May 1955)
 On study course in Scotland.
 K. Raman, M.Sc., Ph.D., *Assistant Soils Chemist*. (23 April 1957)
 K. Ratnasingam, *Assistant Soils Chemist*. (1 January 1960)
 Wong Phui Weng, B.Sc., *Assistant Soils Chemist*. (1 August 1960)

* The date of first appointment to the senior staff is given in brackets after each name.

BOTANICAL DIVISION

- C. W. Brookson, B.Sc., *Head of Division*. (23 August 1949)
 P. de Jonge, I.I., *Botanist*. (29 December 1950)
 P. R. Wycherley, Ph.D., *Botanist*. (26 January 1953)
 J. M. Ross, B.Sc., *Botanist*. (5 December 1955)
 S. G. Boatman, Ph.D., *Botanist*. (2 November 1956)
 J. K. Templeton, M.Agr.Sc., D.Phil., *Botanist*. (24 January 1958)
 E. C. Paardekooper, I.I., *Botanist*. (23 June 1958)
 G. H. Tinley, M.Sc., *Botanist*. (26 November 1958)
 B. R. Buttery, Ph.D., *Botanist*. (18 August 1959)
 C. F. Arlett, Ph.D., *Botanist*. (2 September 1960)
 T. V. Vaidyanathan, B.Agric., *Assistant Botanist*. (1 May 1935) Retired 28 September 1960.
 M. M. Chandapilla, B.Sc., *Assistant Botanist*. (2 January 1958)
 P. D. Abraham, B.Sc. (Agric.), *Assistant Botanist*. (13 October 1958)
 J. B. Gomez, B.Sc., *Assistant Botanist*. (12 September 1960)
 S. K. Majumder, B.Sc., *Assistant Botanist*. (3 October 1960)

PATHOLOGICAL DIVISION

- A. Newsam, Ph.D., *Head of Division*. (5 April 1947)
 R. N. Hilton, M.A., *Pathologist*. (7 September 1948)
 R. A. Fox, B.Sc., B.Agr., *Microbiologist*. (2 March 1954)
 K. P. John, B.A., *Assistant Pathologist*. (16 November 1936)
 B. S. Rao, M.A., D.P.P., *Assistant Entomologist*. (6 June 1952)

CHEMICAL DIVISION

- W. G. Wren, B.Sc., A.R.C.S., D.I.C., A.I.R.I., *Head of Division*. (7 January 1950)
 G. W. Drake, B.Sc., M.A., *Chemist*. (8 March 1948)
 W. A. Southorn, Ph.D., A.R.I.C., *Chemist*. (18 November 1952)
 J. E. Morris, B.Sc., A.R.I.C., *Chemist*. (20 June 1952)
 R. S. Gale, B.Sc., A.C.G.I., A.M.I. Chem. E., *Chemical Engineer*. (2 May 1951)
 D. J. Graham, A.S.T.C., A.R.A.C.I., *Chemical Engineer*. (31 March 1953)
 D. H. Taysum, M.Sc., D.I.C., *Microbiologist*. (13 September 1954)
 G. F. J. Moir, B.Sc., *Biochemist*. (2 February 1955)
 B. C. Sekhar, B.Sc., M.S., A.R.I.C., A.I.R.I., *Polymer Chemist*. (15 September 1949)
 C. A. K. Salgado, B.Sc., A.Inst.P. *Technologist*. (22 April 1957)
 F. W. Shipley, Ph.D., *Chemist*. (6 August 1958) Seconded from N.R.P.R.A.
 T. V. Molesworth, B.Sc., (Tech.), A.M.I. Chem. E., *Chemical Engineer*. (22 April 1957) Resigned 11 June 1960.
 P. S. Nielsen, A.N.C.R.T., *Technologist*. (1 October 1958)
 S. N. Angove, A.N.C.R.T., A.I.R.I., A.P.I., *Technologist*. (26 August 1959)
 R. C. H. Hsia, B.Sc., Ph.D., D.I.C., A.R.I.C., *Analyst*. (2 January 1953)
 J. J. McDonnell, B.Sc., M.Sc., *Biochemist*. (11 January 1960)
 S. Sethu, B.E.(Chem.), M.Sc.(Eng.), A.M.I.Ch.E., *Chemical Engineer*. (1 September 1955)
 S. J. Tata, B.Sc., *Assistant Biochemist*. (14 December 1953)

- A. Karunakaran, B.Sc., *Assistant Biochemist*. (25 November 1957) On study course in U.S.A.
 N. M. Pillai, B.A., F.I.C.S., *Assistant Chemist*. (29 October 1958)
 Mrs R. Pepper, B.Sc., M.Sc., *Microbiologist*. (Temporary appointment 2 January 1959)
 Yeo Oon Keong, M.Sc., A.R.I.C., *Assistant Chemist*. (5 October 1959)
 C. K. John, B.Sc., *Assistant Microbiologist*. (1 January 1960)

SMALLHOLDERS' ADVISORY SERVICE DIVISION

- J. M. F. Greenwood, B.Sc. (Agric.), *Smallholders' Advisory Officer*. (25 November 1948)
 J. G. Samuel, B.Sc. (Agric.), *Assistant Smallholders' Advisory Officer*. (27 December 1956)
 Mohd Johar bin Mohd Rashid, *Assistant Smallholders' Advisory Officer*. (1 August 1958)
 Wong Mun Yun, *Assistant Smallholders' Advisory Officer*. (1 January 1959)
 Yeoh Chong Hoe, B.Sc. (Agric.), *Assistant Smallholders' Advisory Officer*. (1 November 1960)

ESTATES ADVISORY SERVICE DIVISION

- L. R. Davidson, B.Sc. (Agric.), *Head of Service*. (1 December 1940) Resigned 8 October 1960.
 F. W. Hutchison, N.D.A., C.D.A., *Head of Service*. (5 March 1948)
 J. H. Chapman, B.Sc. (Agric.), *Advisory Officer*. (19 August 1955)
 Lim Poh Loh, *Assistant Advisory Officer*. (6 April 1959)
 N. S. Bharathi, B.Sc. (Agric.), *Assistant Advisory Officer*. (4 July 1960)
 Lim Bock Tong, B.Sc. (Agric.), *Assistant Advisory Officer*. (17 October 1960)

BALANCE SHEET A

										31.12.60	As at 31.12.59
LIABILITIES											
										\$ c.	\$
SUNDRY CREDITORS											
Staff	...	...	...	...	...	...	...	...	...	64,933.65	
Merchants	...	...	...	...	...	...	...	...	...	556,805.63	
Miscellaneous	...	...	...	...	...	...	...	...	...	35,864.54	657,603.82
STAFF CONTINGENCY RESERVE FUND											
As at 31 December 1959	...	...	...	...	...	...	...	...	...		330,000.00
EXCESS OF ASSETS OVER LIABILITIES											
As at 31 December 1959	...	...	...	...	...	...	...	...	...	4,904,410.18	
Add Excess of Income over Expenditure for the year:											
Head Office	...	...	...	...	...	...	...	...	...	\$670,628.83	
Experiment Station	...	...	...	...	...	...	...	...	...	168,568.94	839,197.77
Less Written off:											
Furniture	...	...	...	...	...	...	...	...	...	494.00	
Buildings	...	...	...	...	...	...	...	...	...	32,854.32	33,348.32
										5,710,259.63	
Less Original Cost of Replanted Areas transferred from Experiment Station											
...	...	...	...	...	...	...	...	...	...	29,372.00	5,680,887.63

Carried forward 6,668,491.45

5,797,111.11

AT 31 DECEMBER 1960

ASSETS					31.12.60	As at 31.12.59
					\$ c.	\$
LAND AND BUILDINGS						
2½ Mile Compound						
Land as at 31 December 1959					15,784.35	
198 and 200 Ampang Road:						
At nominal value					2.00	15,786
3rd Mile Compound						
Land as at 31 December 1959					31,440.35	
251, 253, 255, 257, 259 and 261 Ampang Road:						
At nominal value					6.00	31,446
3¼ Mile Compound						
Land as at 31 December 1959					27,582.50	
262, 264, 266, 268 and 270 Ampang Road:						
At nominal value					5.00	27,588
4th Mile Compound						
Land as at 31 December 1959					2,000.00	
74, 4th Mile Ampang Road:						
At nominal value					1.00	2,001
Eaton Road Compound						
Land as at 31 December 1959					17,147.08	
1, 3, 5 and 7 Eaton Road:						
At nominal value					4.00	17,151
Wickham Road and Ridley Close						
Land as at 31 December 1959					43,623.50	
9 Bungalows — At nominal value					9.00	43,633
Ukay Heights						
As at 31 December 1959					104,409.39	
Additions during the year					268,203.39	104,409
Ulu Klang						
Land as at 31 December 1959					7,705.00	
Workmen's Quarters — At nominal value					1.00	7,706
Ampang Road Laboratories						
As at 31 December 1959:						
Land					19,526.00	
Buildings					368,090.39	
					387,616.39	
Additions during the year					118,322.10	387,616
Sungei Buloh Laboratories and Houses						
Laboratories as at 31 December 1959					93,697.32	
Additions during the year					15,426.04	
					109,123.36	
Less Written off					5,050.00	
					104,073.36	
Houses as at 31 December 1959 — At nominal value					24.00	93,721
Land and Quarters for Rubber Instructors (under construction)						
As at 31 December 1959:						
Land					10,827.50	
Quarters					98,609.92	
					109,437.42	
Additions during the year					92,968.43	
					202,405.85	
Less Written off					32,854.32	109,438
Carried forward					1,297,510.94	840,495

	31.12.60	As at 31.12.59
	\$ c.	\$
Brought forward	6,668,491.45	5,797,149

Carried forward	<u>6,668,491.45</u>	<u>5,797,149</u>
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								31.12.60	As at 31.12.59
								\$ c.	\$
	Brought forward							1,297,510.94	840,495
Pilot Instruction Centre									
As at 31 December 1959:									
Land							8,297.94		
Buildings							1.00		
							8,298.94		
Additions during the year							9.65	8,308.59	8,299
PLANT AND MACHINERY									
As at 31 December 1959							10,269.88		
Additions during the year							2,164.20	12,434.08	10,270
FURNITURE									
Residential Houses, Kuala Lumpur									
At nominal value							1.00		1
Quarters for Rubber Instructors									
At nominal value							10.00		10
Sungei Buloh									
At nominal value							1.00		1
Offices, Kuala Lumpur									
As at 31 December 1959						1.00			
Additions during the year						494.00			
							495.00		
Less Written off						494.00	1.00		1
Library									
At nominal value							1.00		1
Laboratories									
At nominal value :									
Kuala Lumpur						1.00			
Sungei Buloh						1.00	2.00	16.00	2
APPARATUS AND GLASSWARE									
At nominal value								1.00	1
MOTOR VEHICLES									
At nominal value								1.00	1
WORKSHOP									
At nominal value								1.00	1
LIBRARY BOOKS AND PERIODICALS									
At nominal value								1.00	1
EXPERIMENT STATION DEVELOPMENT									
As at 31 December 1959							3,551,555.45		859,084
Additions during the year							317,573.93		
							3,869,129.38		
Less Government Rubber Replanting Scheme									
Grants						\$ 19,410.00			
Original Cost of Replanted Areas						29,372.00	48,782.00	3,820,347.38	3,551,555
								5,138,620.99	4,410,639
RINIDAD TESTING STATION									
Progress Payments								60,060.00	—
	Carried forward							5,198,680.99	4,410,639

	31.12.60	As at
	\$ c.	31.12.60
		\$
Brought forward	6,668,491.45	5,797,14

REPORT OF THE AUDITORS TO THE BOARD OF THE RUBBER RESEARCH
INSTITUTE OF MALAYA

We have examined the above Balance Sheet with the books and vouchers of the Institute and have obtained all the information and explanations we have required.

Titles to certain of the Institute's lands have not yet been issued.

Subject to the foregoing, in our opinion, the said Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Institute's affairs at 31 December 1960 according to the best of our information and the explanations given to us and as shown by the books of the Institute.

Kuala Lumpur,
May 1961.

Sgd Peat, Marwick, Mitchell & Co.
Chartered Accountants
Certified Public Accountants (Malaya)
Auditors

6,668,491.45

5,797,14

			31.12.60 \$ c.	As at 31.12.59 \$
	Brought forward		5,198,680.99	4,410,639
STOCKS				
Petrol, Oil and Chemicals				
Head Office	...	\$ 356.03		191
Experiment Station	...	15,753.29	16,109.32	9,251
Empty Containers and Drums				
Head Office	...	217.50		133
Experiment Station	...	1,529.00	1,746.50	4,811
Stationery				
Head Office	...		4,608.86	4,534
Sundry Materials				
Head Office	...	17,893.91		15,629
Experiment Station	...	12,200.00	30,093.91	9,788
Rubber				
Experiment Station	...		26,648.31	58,543
				102,880
				4,513,519
			400.00	310
CURRENCY DEPOSITS				
CURRENCY DEBTORS				
Staff				
Loans for Motor Vehicle Purchase	...		365,006.17	286,535
Travelling and Sundries	...		71,048.89	59,966
			436,055.06	
General				
Head Office	...	\$132,165.98		181,993
Experiment Station	...	924.45	133,090.43	277
Interest Accrued on Investments	...		3,674.65	3,675
Payments in Advance				
Head Office	...	12,714.44		4,849
Experiment Station	...	4,094.15	16,808.59	7,047
LOCAL AND BRITISH GOVERNMENT SECURITIES				
(Held for account of Staff Contingency Reserve Fund)				
\$ 15,000/- 4½% Singapore Municipal Debenture Stock 1930-70/80				
(\$17,537/- †) (\$11,474/- *)	...		15,000.00	15,000
\$160,000/- 3% Malayan Union Government Loan 1946-62/66				
(\$160,000/- †) (\$136,996/- *)	...		160,000.00	160,000
£ 20,600/- 3½% British War Loan 1952				
(\$145,322/- †) (\$104,551/- *)	...		145,322.05	145,322
\$ 40,000/- Federation of Malaya 5½% Registered Stock 1979/82				
(\$40,000/- †) (\$35,465/- *)	...		40,000.00	40,000
† Original Cost — \$362,859/-				
* Market Value as at 31 December 1960 — \$294,986/-				
CASH AT BANK AND IN HAND				
At Bank — Current Account	...		430,902.56	
In Hand	...		9,350.22	378,656
			6,668,491.45	5,797,149

Income & Expenditure Account (excluding Experiments)

	31.12.60	Year to 31.12.59
EXPENDITURE	\$ c.	\$
To International Rubber Research Board and International		
Rubber Development Committee	2,142.86	8,571
London Advisory Committee	32,049.46	46,204
Board Meetings	6,106.21	5,099
Salaries of Staff on Agreement:		
Research — Division A \$1,156,859.35		1,050,613
Research — Division B 204,896.94	1,361,756.29	168,159
Salaries of Staff not on Agreement	1,355,291.15	1,264,700
Provident Fund	241,736.58	230,473
Medical	52,848.70	40,697
Travelling	171,568.78	117,680
Office General Charges	64,097.15	73,631
Rents, Rates and Taxes	30,631.06	24,185
Insurance	29,697.61	30,172
Rentals	4,704.00	18,247
Laboratory General Charges	14,807.44	13,201
Buildings and Grounds	207,002.02	176,192
Furniture and Office Equipment	73,894.99	60,420
Fixtures and Fittings	77,794.83	55,684
Plant and Machinery	102,432.83	85,189
Vehicles Maintenance	16,421.05	13,579
Workshop	12,669.68	17,151
Apparatus and Glassware	326,593.98	214,446
Laboratory Chemicals	51,815.43	43,486
Publications	32,376.72	51,421
Library (Books and Periodicals)	35,516.04	28,212
Exhibitions and Conferences	70,906.04	4,896
Smallholders' Advisory Service	1,012,728.04	776,303
Estates Advisory Service	122,986.88	—
Field and Factory Experiments	100,526.77	111,508
Technical Classification	31,888.18	24,278
Gratuities to Staff	72,920.92	56,519
Passages	153,875.26	159,948
Grant towards Passages	865.50	1,784
Scholarship	10,021.23	7,998
Excess of Income over Expenditure for the year	5,880,673.68 670,628.83	4,980,646
	6,551,302.51	4,980,646

Income & Expenditure Account for Experiments

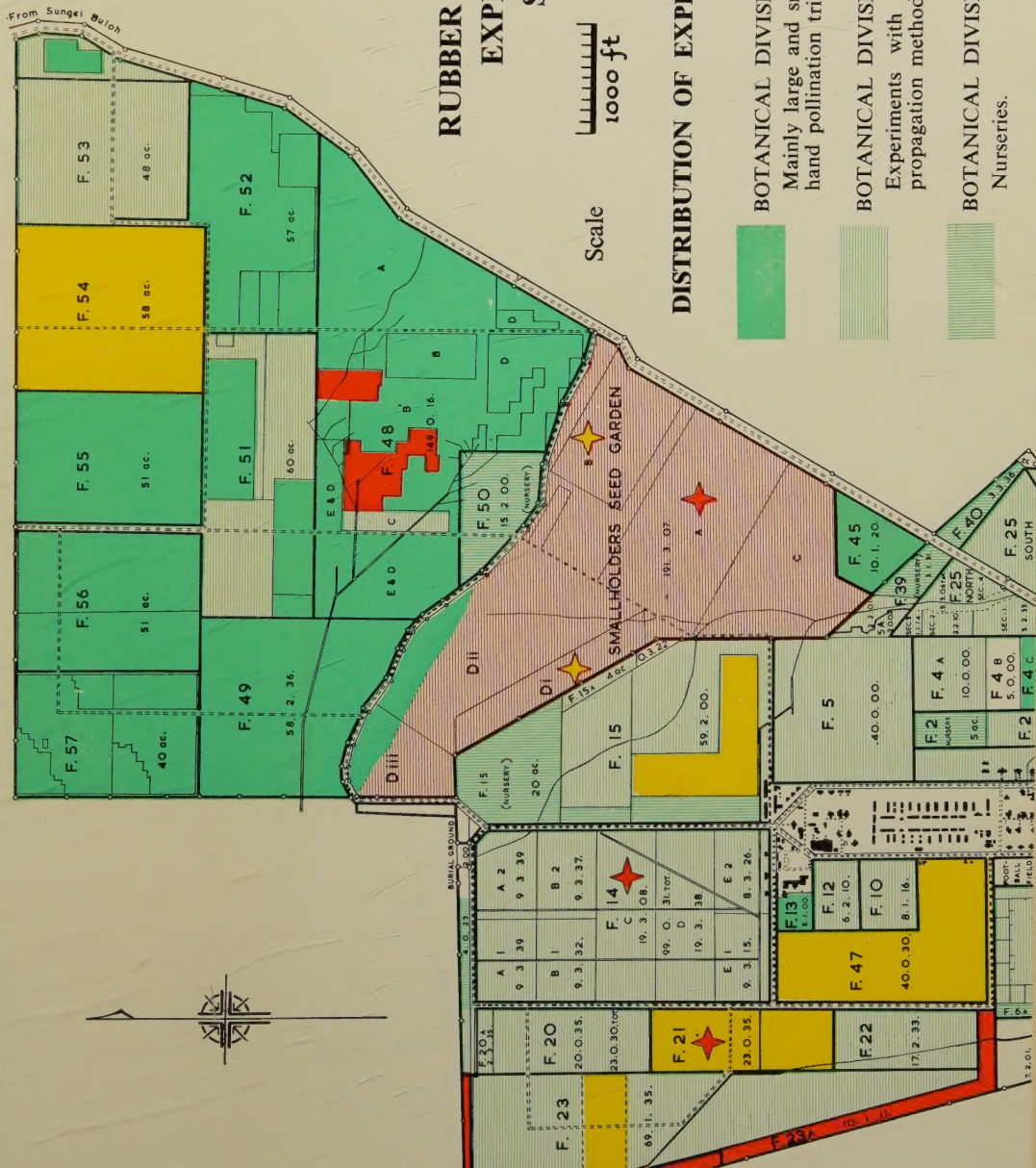
EXPENDITURE	\$ c.	\$
To Revenue Expenditure	1,044,085.01	913,604
Excess of Income over Expenditure for the year	168,568.94	311,628
	1,212,653.95	1,225,232

Station) for the year ended 31 December 1960

INCOME								31.12.60	Year to 31.12.59
								\$ c.	\$
By Contributions received from the Malayan Rubber									
Fund	...	...	...	...	...	...	...	\$6,705,719.00	
Less Amounts not received until 1961	...	...	...	...	...	...	...	242,845.00	4,113,128
Publications Sold	...	...	...	...	...	...	...	33,823.04	40,933
Rents on Houses	...	...	...	...	...	...	...	5,090.75	3,223
Interest on Loans	...	...	...	...	...	...	...	3,943.20	3,638
Interest on Investments	...	...	...	...	...	...	...	13,643.57	21,696
Sundry Fees Received	...	...	...	...	...	...	...	26,660.30	
Miscellaneous	...	...	...	...	...	...	...	5,267.65	28,867
Excess of Expenditure over Income								6,551,302.51	4,211,485
								—	769,161
								6,551,302.51	4,980,646

Station for the year ended 31 December 1960

INCOME								\$ c.	\$
By Sales and Stock of Rubber								1,129,296.63	1,163,954
Sales of Planting Materials	...	...	...	...	...	...	...	31,409.28	26,469
Miscellaneous	...	...	...	...	...	...	...	255.00	180
Rubber Industry Replanting Board :									
Refund on account of Replanting Cesses								51,693.04	34,072
Refund on account of Anti-Inflationary Cesses								—	557
								51,693.04	
								1,212,653.95	1,225,232



SOILS DIVISION.

Manuring and cultivation trials.

SOILS DIVISION.

Experiments superimposed on Smallholders' Seed Garden.

PATHOLOGICAL DIVISION.

Experiments on pests and diseases.

PATHOLOGICAL DIVISION.

Experiments superimposed on existing trials in these fields.

SMALLHOLDERS' SEED GARDEN.

UNCULTIVATED.

